



# FEDERAL WATER QUALITY ADMINISTRATION

NORTHWEST REGION, ALASKA WATER LABORATORY 1610 - 4 - 10/70

PB 197 857

W71-05143

16100 --- 10/70

## THE CHENA RIVER

A STUDY OF A SUBARCTIC STREAM



CLEAN  
WATER

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|   |                   |   |                       |                                                                     |
|---|-------------------|---|-----------------------|---------------------------------------------------------------------|
| 1 | Accession Number  | 2 | Subject Field & Group | <b>SELECTED WATER RESOURCES ABSTRACTS</b><br>INPUT TRANSACTION FORM |
|   | <b>W</b> 71-05143 |   | 05B, 02C, 05C         |                                                                     |

|   |                                                                                 |
|---|---------------------------------------------------------------------------------|
| 5 | Organization                                                                    |
|   | Federal Water Quality Administration, College, Alaska, Alaska Water Laboratory, |

|   |                                                   |
|---|---------------------------------------------------|
| 6 | Title                                             |
|   | THE CHENA RIVER, The Study of a Subarctic Stream, |

|    |                                                   |    |                                                                                                                    |
|----|---------------------------------------------------|----|--------------------------------------------------------------------------------------------------------------------|
| 10 | Author(s)                                         | 16 | Project Designation                                                                                                |
|    | Frey, Paul J; Ernst W Mueller, and Edward C Berry |    | FWQA Project No 1610--10/70                                                                                        |
|    |                                                   | 21 | Note                                                                                                               |
|    |                                                   |    | Available from the National Technical Information Service as PB 197 857, \$3.00 in paper copy, \$0.95 in microfilm |

|    |                                             |
|----|---------------------------------------------|
| 22 | Citation                                    |
|    | October, 1970, 96p, 26 tab, 14 fig, 57 ref, |

|    |                                                                                                                                                                                                                                                                      |
|----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 23 | Descriptors (Starred First)                                                                                                                                                                                                                                          |
|    | Benthos, Chemical oxygen demand, coliform, *Dissolved oxygen, Diversification, Fisheries, *Flood control, Freezing, Nutrients, Plankton, Water pollution sources, Reaeration, Sewage, Temperature, *Water quality, Water pollution effects, *Alaska, Subarctic flow, |

|    |                                                                       |
|----|-----------------------------------------------------------------------|
| 25 | Identifiers (Starred First)                                           |
|    | *Chena River (Alas), Fairbanks (Alas), Break-ups, *Subarctic streams, |

|    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
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| 27 | Abstract                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
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|    | Abstractor                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |

THE CHENA RIVER  
The Study of a Subarctic Stream

by

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FEDERAL WATER QUALITY ADMINISTRATION  
DEPARTMENT OF THE INTERIOR  
ALASKA WATER LABORATORY  
COLLEGE, ALASKA

Project No. 1610---10/70

## ABSTRACT

The Chena River is a subarctic stream flowing westerly from the low mountains of eastern Alaska to the Tanana River near Fairbanks. It is typical of many Interior Alaska rivers with the exception that its lower reaches are highly polluted by domestic and industrial wastes from the Fairbanks area. The purpose of this 3-year study of the river was to understand the physical, chemical, and biological limnology of the river system and what effect man's influence--past, present and future--has on the river. Dissolved oxygen was one of the most critical parameters determined. In the summer it is close to saturation. During winter, in the lower river, the concentration approaches 1 mg/l. The biological community was studied through both quantitative and qualitative plant and animal collections. The upper reaches of the river are much richer in number of kinds of organisms than the lower reaches. Coliform bacteria counts range from very low in the upper river to over 500,000 per 100/ml below Fairbanks.

A flood control dam is planned for the river above the city of Fairbanks. Significant modification of the water quality and biota of the river can be expected following the construction of the dam. Proper management of the flow from the impoundment can reduce the objectionable effects of this dam on the river system.



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## SECTION I

### SUMMARY AND CONCLUSIONS

The Chena River is typical of subarctic rivers that at one time were polluted by goldmining activities which have now been either drastically curtailed or have ceased. At present, the river is relatively clean in its upper 130 miles, but is polluted by domestic wastes in the lower 20 or 30 miles before joining the Tanana River. The following are findings resulting from a 3-year study of the river:

1. The water chemistry of the Chena River is reflective of its drainage from areas of metamorphic rock. Weathered Precambrian schist deposits containing quartz partings contribute silica and iron to the surface waters of the drainage system.
2. Concentrations of nitrogen forms from fixation, both within the river and the adjoining vegetation and soils, are high in relation to phosphorus. Thus, phosphate may be considered as the limiting inorganic nutrient for phytoplankton production.
3. Effect of low light incidence and ice cover in the winter are drastic, resulting in low dissolved oxygen concentrations with associated alterations in the nitrogen cycle and in concentrations of trace metals, particularly iron.
4. Examination of organic material in the river system shows dramatic peaks in the spring due to extensive surface drainage during breakup.
5. The domestic sewage discharge into the Chena River from the Fairbanks area is approximately 3-million gallons per day, with a total biological oxygen demand of about 2,400 pounds per day.
6. Evidence of pollution from sewage is reflected in increases of chemical oxygen demand, phosphates, and chlorides.
7. The total coliform bacteria range from very few in the upper river to more than 500,000 per 100 ml in the lower river indicating gross pollution from the Fairbanks area which has gradually increased over the past several years. The study also indicates that many of the indigenous bacteria of the upper river are incapable of growing at temperatures above 25°C, but when the area of pollution is reached, the number of those capable of growth at this temperature increase sharply.
8. The plankton population in the river is light, consisting predominantly of phytoplankton. The species diversity decreases within the sewage polluted area.
9. Diatoms are predominant in the periphyton. Of special interest are the heavy blooms sometimes witnessed in the winter when air temperatures hover at -40°C.

10. The stations from the middle of the river show the greatest variation in kinds of organisms, while the lower stations show the greatest numbers of organisms.

11. A flood of great magnitude hit the river during the fall of 1967, which greatly changed the diversity of bottom organisms. However, by the following fall, the organisms had redistributed themselves to pre-flood condition.

12. Insects ordinarily intolerant to extremely low dissolved oxygen concentrations were found in fair numbers in the lower river, where oxygen levels fell below 2 mg/l during the winter.

13. Impoundment of the Chena River as a flood control measure could have an immediate and adverse effect on the biota and water quality of the river.

14. Water discharged from the impoundment may be low in dissolved oxygen unless variable level works are provided at the dam, or suitable in-stream reaeration devices are constructed.

15. Presently, the fisheries in the Chena River are entirely of sports interest. The stream, with riffles and pools and abundant numbers of the arctic grayling, is ideal for fly fishermen.

16. Construction of a flood control impoundment will bring about considerable change in the habitat of the fish of the Chena River. Pre-impoundment studies of all species in the Chena River are needed for effective post-impoundment management. The limited king and chum salmon spawning beds are ecologically important and should be enhanced.

17. If the lower Chena River is to be restored to a healthy and aesthetically acceptable body of water, municipal and industrial effluents from the Fairbanks area must be discharged outside of the river drainage.

## SECTION II

### INTRODUCTION

The selection of the Chena River for the first of the streams in the Interior of Alaska for an intensive ecological study was made for a number of reasons. At present, it is a small clear-water stream with no accumulation of glacial silt that tends to modify the fauna and flora of the water course. The stream arises in the low interior mountains of eastern Alaska and drains about 1,980 square miles of both timber and muskeg. Much of the drainage basin is in the permafrost area. Much of the area within the watershed has been burned within the past 30 years, though none recently. At the time of the spring breakup, the stream will overflow the lower portions of the valley. Major floods are a rare occurrence with a limited number within the past 75 years.

A highway system has been developed in the river valley for a distance of some 75 miles of the water course. The number of people resident in the basin above the metropolitan Fairbanks-Fort Wainwright area is less than 100. There is a heavy sports fishing pressure during the months of July and August. The upper reaches have also become a popular camping and picnicking spot. These people have done little to influence the behavior of the stream and its ecology.

A flood control dam and water impoundment is planned for construction about 30 miles upstream from the mouth and this will influence the chemistry and productivity of the stream. In this series of studies, attempts were made to determine the chemical systems present in the water matrix and their sources and cycles in relation to the ecology of the river. Because of ice cover in winter, reaeration rates are low or near zero. In addition, during this time, the low insolation, combined with low temperatures, affects both the photosynthetic and respiration rates. For this reason, chemical and nutrient cycles are affected drastically.

Any limnological study must cover a great many parameters, of which some are more important than others, either to the biota of the stream system or as pollution indicators. As this study was conducted over a period of years, it was possible to conduct such short-term, intensive investigations as were considered necessary during the course of the main study. Nine principal stations were chosen for their biological significance, as well as their proximity to areas of domestic waste introduction. Sampling dates chosen represented seasons which bring about important variations in the river, such as low water, spring breakup, icing conditions, and highly turbid conditions. Parameters measured at these times were the climatic data such as temperature, length of day, precipitation, wind intensity and direction. Chemical analyses included trace elements, chemical oxygen demand, dissolved oxygen, nutrients, both nitrates and phosphates, pH, conductivity, turbidity, alkalinity, hardness, analysis of carbohydrates and proteins, and total organic carbon. Parallel with

this sampling schedule, a complete aquatic biology investigation was carried forward with care to consider the effects of the addition of domestic and industrial pollution. Coliform counts were made both above and below the points of sewage outfalls. This information was sought as a baseline evaluation of the reaction of a subarctic stream when subjected to the stresses of a developing population and its accompanying waste products in the form of domestic sewage and industrial wastes.

Our previous knowledge of the reaction of a stream like the Chena River comes from data and experience with streams in a much less rigorous climate. We are not even sure in this instance that the traditional coliform count is a valid criterion to use as an indicator for pathogenic organisms.



## SECTION III

### RIVER AND BASIN DESCRIPTION

#### Topography and Geology

The Chena River is located in the Yukon plains section of the central Alaskan upland and plains province, longitude 145°W and latitude 65°N (Figure 1). The river drains an area of about 1980 square miles, the extreme width being about 40 miles and the length about 100 miles (Figure 2). Fairbanks, Fort Wainwright, and Eielson Air Force Base border the basin on the southern side; mountains ranging to 5,000 feet border the remaining three sides.

The river originates at the eastern end of the basin at an elevation of about 3,600 feet and flows in a westerly direction for approximately 150 miles, where it joins the Tanana River. The drainage system in the uplands is well developed, having cut deeply into the hills. Most of the exposed rock in the uplands is Birch Creek schist of Precambrian age. Quartz partings have formed in much of the exposed schist and there are a number of intrusions and extrusions of igneous rock of both Precambrian and Mesozoic age. In the lower 100 miles, the river meanders through a broad alluvial valley. At an early geologic date, this valley was filled with sand and gravel composed of the more durable pieces of schist, quartz and igneous rock derived from the uplands. Later, the area was blanketed with a thick covering of windblown loess which has been highly eroded in the valleys. Borings in the valley show that the surface moss is about 1-foot thick and is underlain with about 18 inches of silt and peat over sand and gravel frozen perennially to a great depth. The sand and gravel beds in the lower valley have been found to be over 300 feet deep (Pewe, 1958).

#### Vegetation

The natural vegetation in the basin ranges from light to very heavy. It is composed of heavy stands of white spruce (Picea glauca) and cottonwood (Populus tacamahaca) on favorable sites along the river (Figure 3), and mostly scattered, small black spruce (Picea mariana), birch, (Betula papyrifera), aspen (Populus tremuloides), and larch (Larix laricina), with a thick undergrowth of willow (Salix sp.), and alder (Alnus sp.), in less favorable sites (Figure 4). The flood plain has numerous swamps and peat bogs (Figure 5). The ground cover in these areas includes laborador tea (Ledum palustre), dwarf willow (Salix sp.), sphagnum moss (Sphagnum sp.), lichen (Cladonia sp.), dwarf birch (Betula nana), blueberry (Vaccinium uliginosum), wild rose (Rosaceae sp.), as well as other shrubs and plants. On higher, better drained soil with a low permafrost table, the common ground cover includes high bush cranberry (Viburnum edule), low bush cranberry (Vaccinium



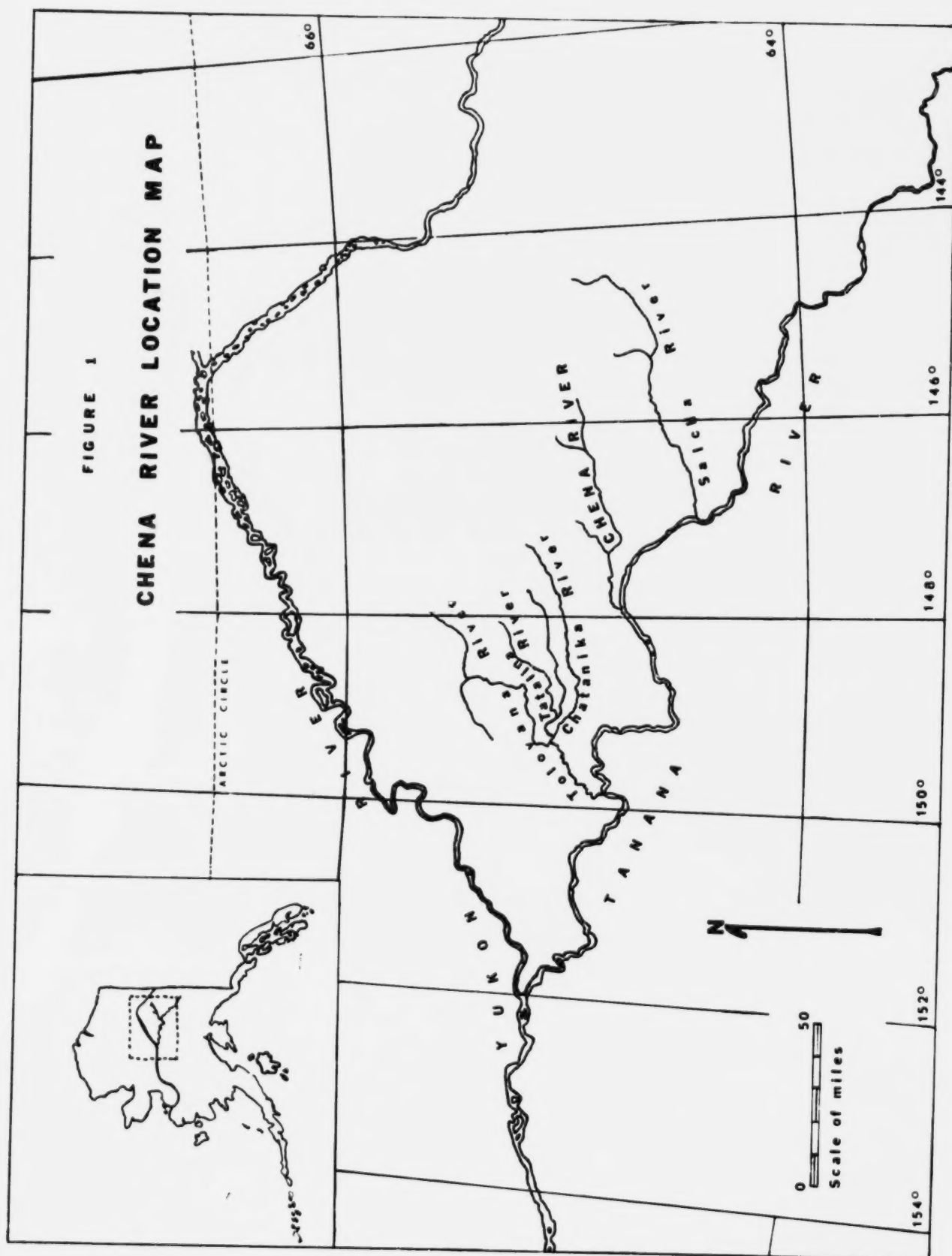


Figure 2  
CHENA RIVER DRAINAGE BASIN

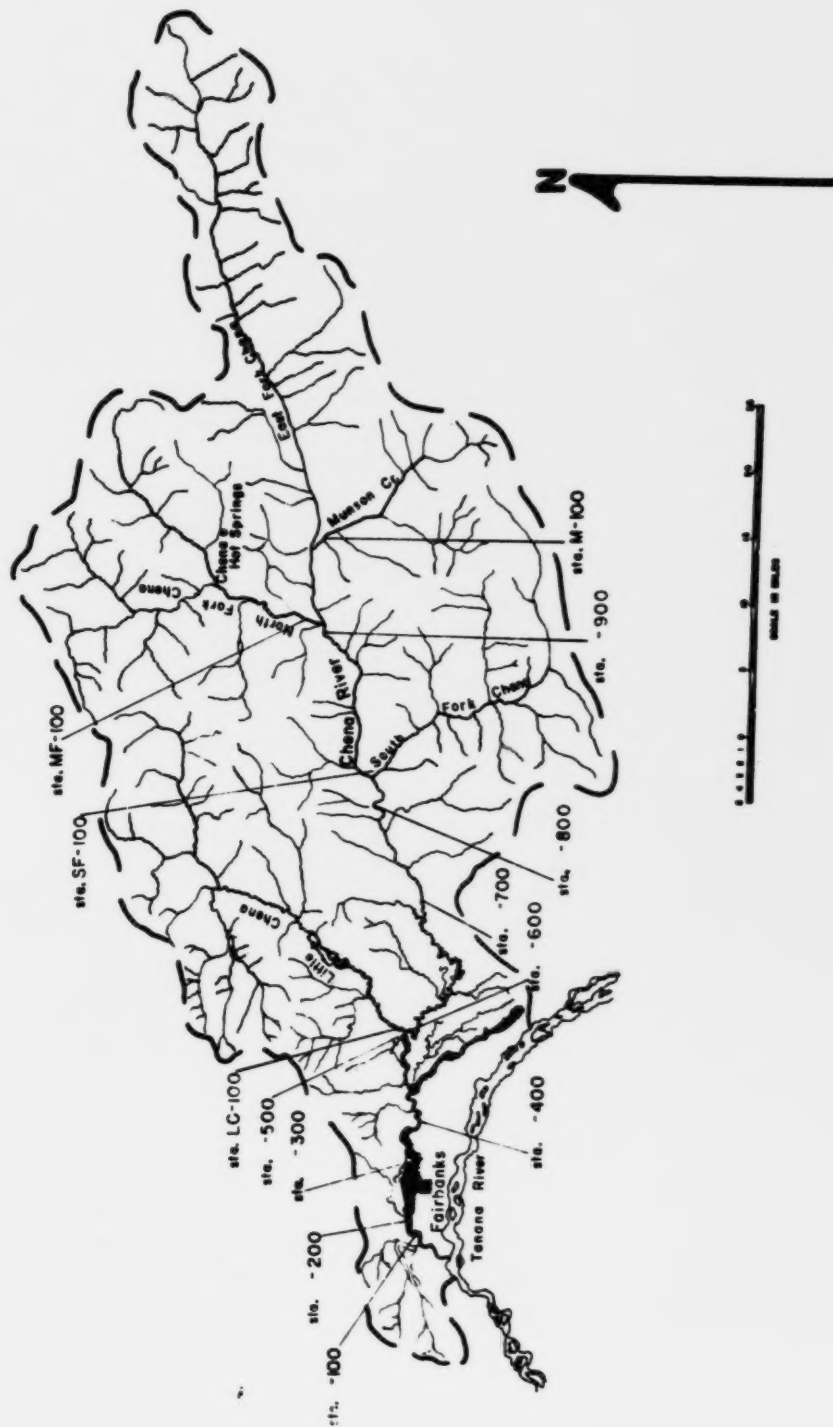




Figure 3. Heavy stands of spruce and poplar in favorable sites along the Chena River.



Figure 4. Alders and black spruce in winter on the upper Chena River

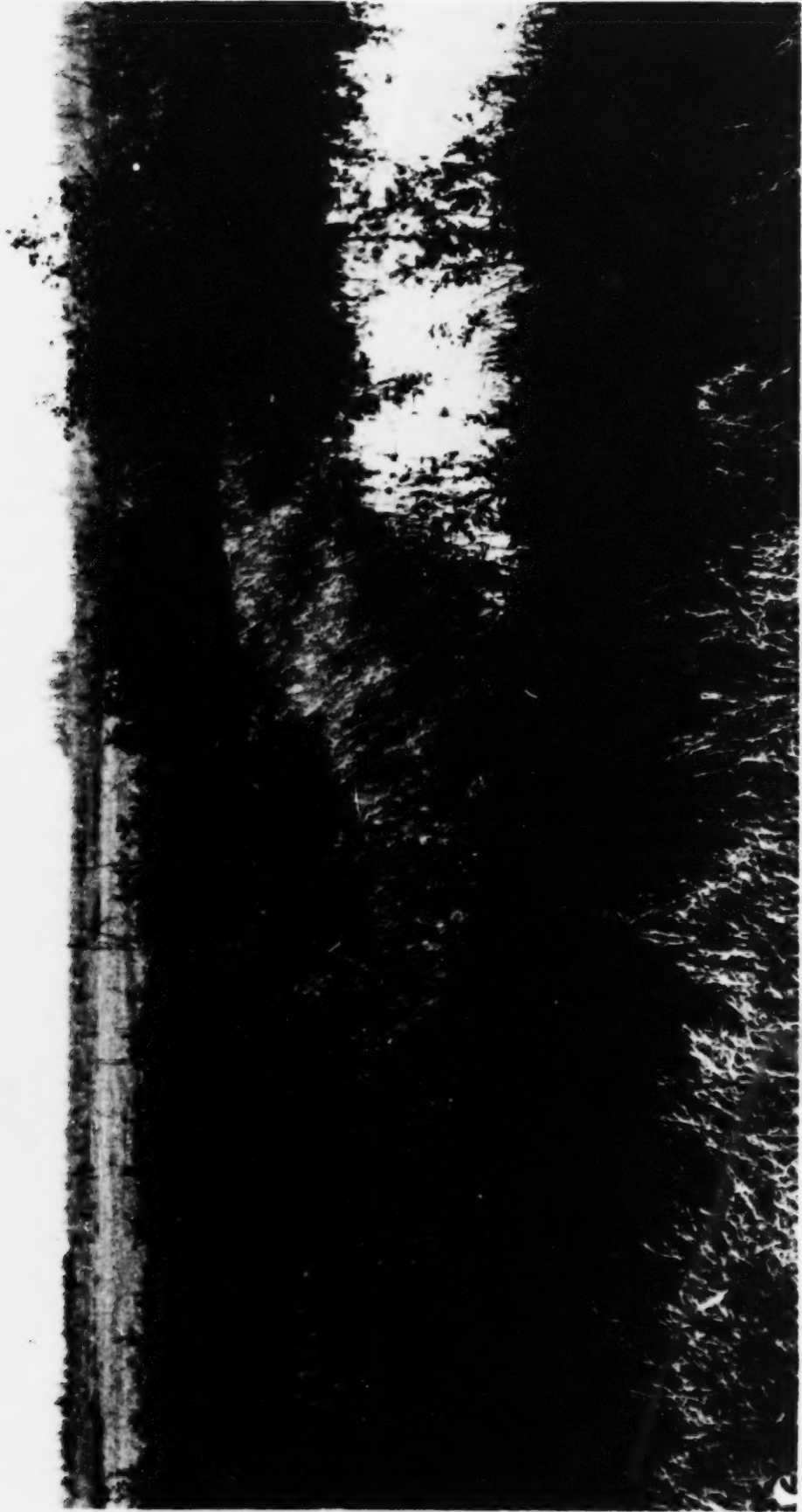


Figure 5. Flood plain with swamps and peat bogs



Vitus-ideae), twinberry (Linnaea borealis), bear berry (Arctostaphylos uva-ursi), dwarf dogwood (Cornus canadensis), Bluejoint (Calamagrotis canadensis), horsetail (Equisetum arvense), fireweed (Epilobium angustifolium), and sandwort (Arenaria sp.), as members of the plant population.

### Climate

The climate of the Chena basin is influenced by the large mountains lying to the south which form an effective barrier to the flow of warm moist air from the north Pacific Ocean. Because of the lack of moderating influence of maritime air, greater temperature extremes occur here than along the coast. The extreme low temperatures in the winter are caused by the polar air masses that flow in from the north.

The average annual temperature in Fairbanks is 26°F. The average annual temperatures within the Chena basin varies from 36°F to 15°F at various locations. In Fairbanks, the all-time low officially recorded was -66°F in January 1934, and the highest temperature on record is 99°F in July 1919. The growing season, which is the average number of days between the last frost of spring and the first frost in fall, is approximately 4 months (Table 1). During periods of extreme cold, a temperature inversion exists in the lower layers of the atmosphere. Under this condition, warmer temperatures prevail on the mountain slopes than in the lowlands. The air temperature increases sharply to 2,000 feet then gradually decreases to surface temperatures at about 10,000 feet. In the summer, the temperature decreases with an increase in elevation in the normal manner (Billelo, 1966) (Table 2).

Since the flow of moist air is generally from the south, the large mountain barriers receive most of the precipitation and the carryover into the Chena basin is small. The average precipitation for the Chena basin is about 10 inches per year, with the maximum monthly precipitation usually occurring in July or August and the minimum between February and April. The mean annual snowfall is 6 feet with great variations between the years. Moisture received in this manner comprises about 40 percent of the annual precipitation.

The average annual mean wind velocity for Fairbanks is 5 miles per hour and the maximum recorded is 60 mph in March 1948. Prevailing wind direction is from the north, but maximum winds usually come from the southwest.

### Land Use

The headwaters of the Chena River and most of its tributaries remain in a relatively unpolluted condition. However, at the turn of the century, gold was discovered on one of the tributaries of the Chatanika River.



TABLE 1  
AVERAGE AIR TEMPERATURE DATA FOR FAIRBANKS, ALASKA  
FROM 1903-1969, F

|                 | JAN   | FEB   | MAR   | APR   | MAY   | JUNE | JULY | AUG  | SEPT | OCT   | NOV   | DEC   | ANNUAL |
|-----------------|-------|-------|-------|-------|-------|------|------|------|------|-------|-------|-------|--------|
| Mean            | -11.1 | - 2.9 | 8.9   | 29.4  | 47.1  | 58.4 | 59.7 | 54.3 | 43.6 | 26.2  | 3.9   | - 7.7 | 25.8   |
| Highest         | 38.0  | 42.0  | 48.0  | 63.0  | 81.0  | 96.0 | 89.0 | 85.0 | 80.0 | 65.0  | 42.0  | 42.0  | 96.0   |
| Lowest          | -61.0 | -56.0 | -46.0 | -21.0 | - 1.0 | 37.0 | 37.0 | 30.0 | 16.0 | -15.0 | -43.0 | -56.0 | -61.0  |
| Average Maximum | - .8  | 9.5   | 23.5  | 42.1  | 59.1  | 71.1 | 71.7 | 65.3 | 53.9 | 35.4  | 13.4  | 2.1   | 37.2   |
| Average Minimum | -21.5 | -15.3 | - 5.7 | 16.6  | 35.1  | 45.6 | 47.6 | 43.2 | 33.3 | 17.0  | - 5.6 | -17.5 | 14.4   |

U.S. Weather Bureau, Fairbanks, Alaska

TABLE 2

DIURNAL VARIATION INVERSIONS AT FAIRBANKS  
2400Z and 1200Z (1400 and 0200 local mean time)

| MONTH | Ave. Temperature Gradient, °C |       | SURFACE INVERSIONS |     |       |                    | INVERSIONS ABOVE SURFACE |     |       |                    |
|-------|-------------------------------|-------|--------------------|-----|-------|--------------------|--------------------------|-----|-------|--------------------|
|       | Day                           | Night | Frequency (%)      | Day | Night | Ave. Thickness (M) | Frequency (%)            | Day | Night | Height of Base (M) |
| JAN   | 2.6                           | 3.4   | 81                 | 84  | 690   | 640                | 15                       | 14  | 410   | 410                |
| FEB   | 1.8                           | 3.0   | 56                 | 83  | 480   | 560                | 38                       | 15  | 540   | 440                |
| MAR   | 1.3                           | 3.0   | 30                 | 86  | 190   | 420                | 46                       | 11  | 720   | 570                |
| APR   | 0.8                           | 1.9   | 6                  | 80  | 120   | 310                | 24                       | 12  | 980   | 880                |
| MAY   | ---                           | 1.5   | --                 | 72  | ---   | 240                | 3                        | 11  | 1120  | 660                |
| JUNE  | 1.1                           | 1.4   | 1                  | 62  | 150   | 280                | 1                        | 8   | 1100  | 390                |
| JULY  | 0.6                           | 1.3   | 1                  | 62  | 180   | 320                | 14                       | 8   | 1100  | 280                |
| AUG   | 0.7                           | 1.3   | 1                  | 69  | 170   | 310                | 3                        | 5   | 1220  | 400                |
| SEPT  | 0.7                           | 1.5   | 5                  | 71  | 130   | 290                | 14                       | 8   | 880   | 850                |
| OCT   | 1.4                           | 2.1   | 28                 | 67  | 230   | 350                | 43                       | 19  | 740   | 740                |
| NOV   | 2.6                           | 2.7   | 66                 | 78  | 440   | 500                | 29                       | 20  | 500   | 520                |
| DEC   | 2.6                           | 3.2   | 82                 | 82  | 680   | 610                | 16                       | 15  | 370   | 370                |

Bilello (1966)

As a result, Fairbanks, Alaska's second largest city, has grown on the banks of the Chena and agriculture and other land uses have developed. Gold mining, with its resultant heavy silt load in the river, reached a high point in 1910, but has dwindled until only two operations are still active. There have been a considerable number of gravel washing operations in the lower river, and several are still in operation.

Prior to 1950, agriculture was negligible, but in the middle 1950's, there was a surge of activity and approximately 7,000 acres of land was cleared and a moderate amount of farming was in progress. The major crop was potatoes, with dairying second and grain crops third. Since then, these efforts have also been reduced until only about 1,700 acres remain under cultivation.

During the recent history of the basin, numerous forest fires have burned over large portions of the watershed. Until recently, lumbering in the watershed has been at a minimum. However, at present, there is considerable lumbering activity in the heavy stands of white spruce along the upper river.

Habitation in the upper 120 miles of the river basin is limited to less than 100 people. Downstream from the confluence of the Little Chena, habitation increases, reaching a maximum in the Fairbanks-Fort Wainwright area. The total population in this lower area approaches 40,000, manifesting itself in high coliform counts in the river. Although the river is still grossly polluted, there has been an improvement in the overall condition of the ecology in the lower river during the past 15 years (Frey, 1969).

#### Stream Bed

The major tributaries of the Chena are Munson Creek, North Fork, South Fork, and the Little Chena, which are fed by many small creeks. The river has an average slope of 23-feet-per-mile from about river mile 140-125, 11.4 feet-per-mile from river mile 125-90, 6.2 feet-per-mile from river mile 90-50, and 1.5 feet-per-mile from that point to its mouth.

The river, in its upper reaches, is characterized by a succession of deep, wide, slow-moving pools, long shallow runs, and many short, steep riffles. The bottom of the pools usually consists of cleanly washed sand with a few large boulders occurring occasionally (Figure 6). The runs and riffles are characterized by heavy rubble and gravel (Figure 7). Downstream, where the river meanders considerably (Figure 8), it becomes wider and deeper with slower moving water with only occasional riffles.



Figure 6. Cleanly washed sand and gravel in bottom of pools



Figure 7. Runs and riffles are characteristic of the upper Chena River



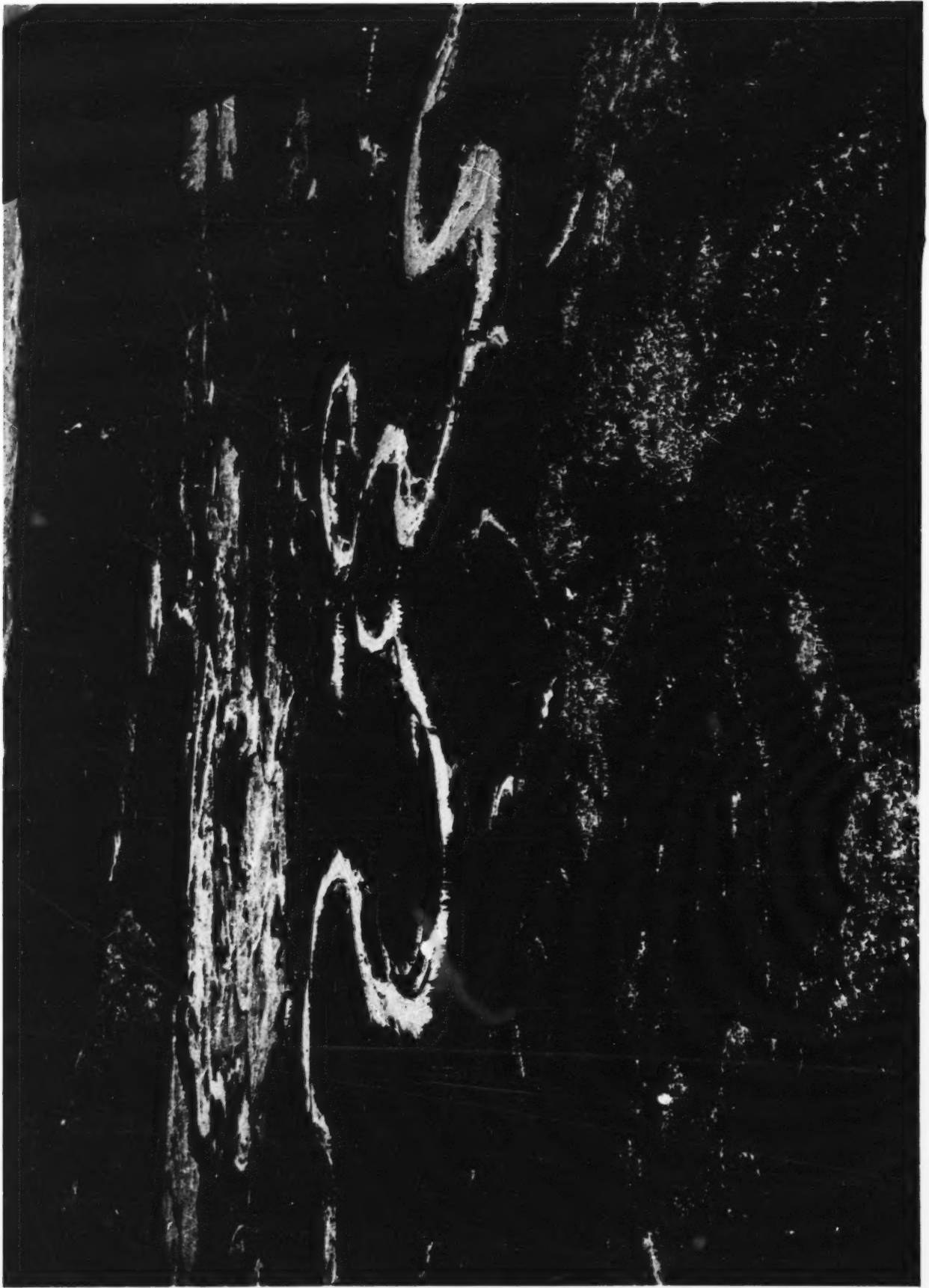


Figure 8. Meandering of the Lower Chena River

## Flow

The U.S. Geological Survey has maintained a stream gaging station on the lower Chena River at Fairbanks since 1947. Since that time, the average annual flow has been 1,568 cfs, with a maximum annual flow of 3,160 cfs, in 1949, and a minimum of 708 cfs in 1958 (Table 3). The average annual runoff in acre-feet and inches is 1,079,000 acre-feet and 10.21 inches (Table 4). Total flow time from river mile 98.4 to the mouth just prior to breakup in 1968 was 229 hours. The flow time was obtained by the use of Rhodamine B as a tracer (Table 5).

The discharge pattern of the Chena is typical of snow melt streams. Low flows occur in the winter during freezeup, then gradually increase in the spring. As breakup approaches, there is a more rapid increase, at which time the high for the year is normally reached. These high flows, during which time the winter snow melts, usually last for about 2 weeks. Throughout most of the summer, there is a general decrease in flow. As the summer progresses into fall, precipitation increases, causing an increase in flow. Summer flooding is unusual; however, the all-time high of 74,400 cfs recorded for the river occurred in August 1967 (USACE, 1967).

## Suspended Sediment

The sediment load in the Chena River was very high during the gold mining era. At that time, there was also some intrusion of the Tanana River, which is heavily laden with glacial silt. With the construction of the Moose Creek dike and a reduction in gold mining, the turbidity of the Chena has been greatly reduced. Records from the U.S. Geological Survey gaging station in Fairbanks show the maximum monthly average of 204 ppm occurring in May and the minimum of an undetectable amount occurring in January, February and March (Table 6). Although there is very little sand and silt present during low flow, this inorganic material does appear during high flow. Observations of very firm stream beds have caused the U.S. Geological Survey to conclude that there is insignificant stream bed movement in the Chena.

During the gold mining era, it was reported that extensive silt banks were evident from the mouth of the Little Chena to the Tanana River. Since the reduction in mining, the river has reverted to its original cleanly-washed gravel bed except for a stretch below the mouth of Cripple Creek. This is a very slow-moving reach and the heavy silt load from gold mining activities on Cripple Creek is deposited in the river bed. In years when there is sufficient water for mining on Cripple Creek, an extensive silt bank is formed in the Chena River (Figure 9). High water during spring breakup flushes the silt bank away before the following year's operation begins.

TABLE 3  
AVERAGE MONTHLY FLOW OF THE CHENA RIVER AT FAIRBANKS  
(Flow in cfs)

| WATER<br>YEAR | OCT  | NOV | DEC | JAN | FEB | MAR | APR | MAY   | JUNE | JULY | AUG   | SEPT | ANNUAL |
|---------------|------|-----|-----|-----|-----|-----|-----|-------|------|------|-------|------|--------|
| 1948          | --   | --  | --  | --  | --  | --  | --  | 10250 | 5527 | 3881 | 4675  | 2798 | --     |
| 1949          | 1353 | 631 | 440 | 390 | 355 | 365 | 407 | 6440  | 6721 | 6133 | 3812  | 1701 | 2376   |
| 1950          | 1006 | 670 | 412 | 330 | 312 | 305 | 423 | 4951  | 1812 | 1258 | 1392  | 1066 | 1073   |
| 1951          | 863  | 592 | 454 | 334 | 325 | 243 | 516 | 3474  | 1895 | 1608 | 1205  | 1578 | 1083   |
| 1952          | 881  | 593 | 438 | 330 | 310 | 300 | 377 | 3383  | 3554 | 2957 | 2645  | 3380 | 1596   |
| 1953          | 1488 | 600 | 460 | 218 | 120 | 140 | 365 | 2151  | 1556 | 2114 | 1869  | 2660 | 1146   |
| 1954          | 1139 | 410 | 290 | 200 | 150 | 150 | 290 | 1799  | 1629 | 1842 | 1619  | 1967 | 957    |
| 1955          | 1206 | 640 | 470 | 350 | 270 | 240 | 255 | 4279  | 4828 | 2794 | 3050  | 3918 | 1858   |
| 1956          | 1508 | 505 | 420 | 340 | 290 | 270 | 634 | 6045  | 2855 | 1268 | 4046  | 2702 | 1740   |
| 1957          | 1351 | 425 | 299 | 270 | 289 | 290 | 458 | 5484  | 1409 | 1010 | 682   | 615  | 1056   |
| 1958          | 479  | 311 | 240 | 254 | 151 | 289 | 344 | 2652  | 1021 | 665  | 1425  | 833  | 708    |
| 1959          | 568  | 297 | 276 | 202 | 183 | 151 | 212 | 4583  | 1318 | 3190 | 1755  | 2005 | 1230   |
| 1960          | 1394 | 616 | 449 | 425 | 325 | 183 | 315 | 3474  | 1223 | 1107 | 1348  | 2352 | 1107   |
| 1961          | 1976 | 575 | 541 | 441 | 260 | 325 | 282 | 3600  | 2336 | 1874 | 5355  | 3586 | 1751   |
| 1962          | 2413 | 900 | 600 | 500 | 440 | 260 | 400 | 7398  | 5234 | 3437 | 3650  | 5735 | 2603   |
| 1963          | 1811 | 510 | 306 | 327 | 361 | 440 | 375 | 8600  | 3647 | 2559 | 4325  | 1915 | 2112   |
| 1964          | 1123 | 560 | 440 | 310 | 240 | 361 | 240 | 1796  | 6210 | 2498 | 2069  | 2569 | 1520   |
| 1965          | 1058 | 375 | 303 | 325 | 278 | 240 | 755 | 2830  | 2812 | 2502 | 2358  | 3116 | 1419   |
| 1966          | 1664 | 687 | 480 | 365 | 330 | 278 | 401 | 5177  | 3404 | 1265 | 766   | 650  | 1293   |
| 1967          | 459  | 311 | 282 | 249 | 224 | 330 | 276 | 5215  | 3513 | 3204 | 20847 | 3387 | 3160   |

U.S. Geological Survey, Fairbanks, Alaska

TABLE 4  
DISCHARGE AND RUNOFF DATA FOR  
THE CHENA RIVER AT FAIRBANKS

| WATER YEAR | ANNUAL RUNOFF    |        |
|------------|------------------|--------|
|            | Acre Feet (1000) | Inches |
| 1949       | 1774             | 16.54  |
| 1950       | 847              | 8.02   |
| 1951       | 789              | 7.47   |
| 1952       | 1160             | 11.00  |
| 1953       | 834              | 7.90   |
| 1954       | 697              | 6.60   |
| 1955       | 1350             | 12.78  |
| 1956       | 1250             | 12.02  |
| 1957       | 771              | 7.30   |
| 1958       | 516              | 4.89   |
| 1959       | 899              | 8.51   |
| 1960       | 806              | 7.63   |
| 1961       | 1277             | 12.09  |
| 1962       | 1885             | 17.85  |
| 1963       | 1529             | 14.48  |
| 1964       | 1103             | 10.44  |
| 1965       | 1027             | 9.73   |
| 1966       | 932              | 8.83   |
| Average    | 1079             | 10.21  |
| Maximum    | 1885             | 17.85  |
| Minimum    | 516              | 4.89   |

U.S. Geological Survey

TABLE 5  
FLOW TIME FOR THE CHENA RIVER  
IN APRIL-MAY 1968

| STATION | VOLUME<br>cfs | INSTANT-FLOW<br>F/S | DISTANCE OF<br>TRAVEL | FLOW TIME |     |
|---------|---------------|---------------------|-----------------------|-----------|-----|
|         |               |                     |                       | hrs       | min |
| 900     | 104           | ----                | ----                  | ---       | --- |
| 800     | 164           | 0.22                | 17.0                  | 18        | 35  |
| 700     | 163           | 2.09                | 12.5                  | 20        | 40  |
| 600     | 197           | 1.78                | 36.5                  | 132       | --  |
| 500     | 270           | 0.43                | 1.3                   | 2         | 23  |
| 400     | 371           | 0.45                | 5.0                   | 11        | 9   |
| 300     | 389           | 0.96                | 8.8                   | 23        | 56  |
| 200     | 389           | 1.79                | 4.0                   | 14        | 46  |
| 100     | 460           | 1.74                | 1.6                   | 4         | 20  |
| TOTAL   |               |                     | 86.7                  | 227       | 49  |

Rhodamine-B Dye Tracer Technique

U.S. Geological Survey, 1968





Figure 9. Silt bank caused by gold mining on Cripple Creek

TABLE 6

SUSPENDED SEDIMENT IN THE CHENA RIVER  
AT FAIRBANKS, ALASKA

1966 Water Year

(Where no concentrations are reported, loads are estimated)

|                | MEAN<br>DISCHARGE<br>(cfs) | SUSPENDED SEDIMENT |      |     | Tons Per Day |
|----------------|----------------------------|--------------------|------|-----|--------------|
|                |                            | Average            | High | Low |              |
| October 1965   | 1364                       | 39                 | 190  | 10  | 85           |
| November 1965  | 687                        | 15                 | 27   | 10  | 27           |
| December 1965  | 511                        | ---                | 20   | --  | 13           |
| January 1966   | 376                        | ---                |      |     | 5            |
| February 1966  | 330                        | ---                |      |     | 4            |
| March 1966     | 328                        | ---                | 34   | --  | 7            |
| April 1966     | 401                        | 25                 | 32   | 14  | 21           |
| May 1966       | 3915                       | 147                | 390  | 14  | 2850         |
| June 1966      | 3404                       | 62                 | 330  | 21  | 724          |
| July 1966      | 1265                       | 14                 | 19   | 10  | 47           |
| August 1966    | 767                        | 15                 | 27   | 11  | 32           |
| September 1966 | 650                        | 17                 | 29   | 10  | 30           |

390 - May 12

Below 10 - December-March

U.S. Geological Survey

## Water Temperature

Water temperatures were taken at weekly intervals from various stations in 1966, 1967, and 1968. The maximum temperature recorded for the 3-year period of this series of data was 17.6°C on July 25, 1968. Temperatures of this level are of very short duration and comparatively rare.

Minimum river water temperatures approach 0.0°C in October and remain until about April. The temperature then rises slowly until breakup, usually about the middle of May. After breakup, the temperature rises to a peak in the middle of July (Table 7).

## Pollution Sources on the Lower River

A survey of the sources of pollution to the lower Chena River was conducted during the summer of 1968. It was beyond the scope of this survey to obtain a truly accurate figure of the waste loads being discharged into the Chena River. This would have involved an extensive sampling and monitoring program. In the absence of such an extensive effort, a relatively simple method was developed which can be utilized to monitor the level of wastes being discharged into the river.

Procedures: Officials of the City of Fairbanks, College Utilities Corporation and Fort Wainwright sewage treatment plants were contacted to obtain discharge flows and biochemical oxygen demand (B.O.D.) rates for wastes going into the river. The lower river was surveyed by river boat. Houses adjacent to the river and sloughs were counted and it was assumed that sewage from these dwellings was reaching the river directly or through a septic tank. The estimated waste load per dwelling was based upon a figure of 50 gallons per capita per day and an average of three persons per dwelling.

The Noyes Slough and Chena Slough were treated as separate sources of pollution on the main river. It was assumed that there would be some reduction of B.O.D. in the sloughs before it reached the main river. Therefore, a figure of 200 ppm for the final B.O.D. was used instead of 300 ppm, the average of officially reported sources for raw sewage.

Results: The results of the survey are shown in Table 8 and Figure 10. Table 8 summarizes all the pollution sources noted and gives the flow and waste loading of each. Sewage flows are expressed as B.O.D. values while other waste sources are described separately.

The survey shows that the total sewage flow into the Chena River is approximately 3-million gallons per day for a total B.O.D. addition of 2,400 pounds per day. Over 90 percent of the total B.O.D. loading added to the lower Chena River comes from the Fort Wainwright and Fairbanks municipal primary sewage treatment plants.

TABLE 7  
WEEKLY WATER TEMPERATURES FROM FOUR STATIONS  
ON THE CHENA RIVER, 1966-68

| DATE               | STATION |      |      |      |
|--------------------|---------|------|------|------|
|                    | 100     | 200  | 300  | 400  |
| April 19, 1966     | 1.0°C   | 1.4  | 1.5  | -    |
| April 28, 1966     | 3.8     | 3.5  | 2.4  | -    |
| May 3, 1966        | 4.0     | 3.0  | 3.0  | -    |
| May 10, 1966       | 2.3     | 2.0  | 1.4  | -    |
| May 17, 1966       | 2.9     | 2.9  | 3.2  | -    |
| May 24, 1966       | 5.4     | 6.1  | 5.8  | -    |
| May 31, 1966       | 7.9     | 7.2  | 7.6  | -    |
| June 7, 1966       | 11.0    | 11.0 | 10.8 | -    |
| June 14, 1966      | 12.3    | 11.7 | 11.5 | -    |
| June 21, 1966      | 11.4    | 10.2 | 10.4 | -    |
| June 28, 1966      | 13.0    | 12.6 | 11.9 | -    |
| July 5, 1966       | 16.4    | 14.4 | 14.2 | 14.1 |
| July 12, 1966      | 14.7    | 13.3 | 13.2 | 12.7 |
| July 19, 1966      | 14.3    | 13.8 | 13.8 | 12.7 |
| July 26, 1966      | 15.8    | 15.8 | 15.1 | 14.9 |
| August 2, 1966     | 14.0    | 13.4 | 13.5 | 13.2 |
| August 9, 1966     | 15.3    | 14.1 | 13.6 | 11.0 |
| August 16, 1966    | 10.3    | 10.4 | 10.2 | 7.8  |
| August 24, 1966    | 10.4    | 10.5 | 10.5 | -    |
| August 30, 1966    | 11.5    | 10.4 | 10.0 | -    |
| September 6, 1966  | 9.7     | 12.6 | 8.4  | 6.6  |
| September 13, 1966 | 7.3     | 7.2  | 7.1  | 6.8  |
| September 22, 1966 | 6.4     | 7.0  | 6.8  | 5.0  |
| September 27, 1966 | 7.5     | 8.0  | 7.8  | 5.3  |
| October 3, 1966    | 6.0     | 6.0  | 5.5  | 4.5  |
| October 11, 1966   | -       | -    | -    | -    |
| October 18, 1966   | 1.0     | 1.1  | 0.4  | 0.2  |
| October 28, 1966   | 0.4     | 0.4  | 0.2  | 0.8  |
| November 1, 1966   | 0.4     | 0.3  | 0.6  | 0.05 |
| November 8, 1966   | 0.3     | 0.9  | 0.4  | 0.0  |
| November 15, 1966  | -       | 0.7  | 0.0  | -    |
| November 22, 1966  | 0.5     | 0.9  | 0.8  | 0.0  |
| November 29, 1966  | 0.4     | 0.0  | 0.0  | 0.0  |
| December 5, 1966   | 0.0     | 0.0  | 0.0  | 0.0  |
| March 7, 1967      | 0.4     | 0.5  | 0.3  | 0.1  |
| March 14, 1967     | 0.6     | 0.3  | 0.7  | 0.2  |
| March 21, 1967     | 0.3     | 0.4  | 0.5  | 0.6  |
| March 28, 1967     | 0.4     | 1.1  | 0.4  | 0.3  |
| April 4, 1967      | 0.5     | 1.0  | 0.4  | 0.5  |
| April 11, 1967     | 0.7     | 1.2  | 0.4  | 0.2  |

TABLE 7 Cont.

| DATE               | STATION |      |      |      |
|--------------------|---------|------|------|------|
|                    | 100     | 200  | 300  | 400  |
| April 18, 1967     | 1.2°C   | 2.2  | 0.6  | 0.5  |
| April 26, 1967     | 2.1     | 2.3  | 0.7  | 0.2  |
| May 2, 1967        | 2.6     | 2.1  | 1.0  | 0.3  |
| May 10, 1967       | 2.5     | 2.1  | 2.0  | 2.3  |
| May 17, 1967       | 3.5     | 2.7  | 2.4  | 2.8  |
| May 24, 1967       | 3.9     | 3.6  | 3.5  | 3.1  |
| May 31, 1967       | 6.4     | 6.1  | 6.1  | 5.4  |
| September 12, 1967 | 4.9     | 4.8  | 4.6  | 4.8  |
| September 18, 1967 | 5.9     | 5.7  | 5.4  | 5.9  |
| September 26, 1967 | 3.9     | 3.9  | 3.7  | 3.7  |
| October 3, 1967    | 2.5     | 2.5  | 2.4  | 2.5  |
| October 10, 1967   | 0.1     | 0.2  | 0.0  | 0.0  |
| October 18, 1967   | 0.1     | 0.2  | 0.1  | 0.1  |
| October 24, 1967   | 0.0     | 0.1  | 0.0  | 0.0  |
| October 31, 1967   | 0.0     | 0.0  | 0.0  | 0.0  |
| January 2, 1968    | 0.1     | 0.5  | 0.1  | 0.1  |
| January 9, 1968    | 0.1     | 0.1  | 0.1  | 0.1  |
| January 25, 1968   | 0.1     | 0.1  | -    | 0.1  |
| January 31, 1968   | 0.1     | 0.1  | 0.1  | 0.1  |
| February 8, 1968   | 0.1     | 0.1  | 0.1  | 0.1  |
| February 15, 1968  | 0.1     | 0.1  | 0.1  | 0.1  |
| February 28, 1968  | -       | -    | 0.1  | 0.1  |
| March 7, 1968      | 0.1     | 0.1  | 0.1  | 0.1  |
| March 14, 1968     | 0.1     | 0.1  | 0.1  | 0.1  |
| March 21, 1968     | 0.2     | 0.2  | 0.1  | 0.1  |
| March 28, 1968     | 0.1     | 0.2  | 0.2  | 0.1  |
| April 4, 1968      | 0.1     | 0.2  | 0.2  | 0.1  |
| April 11, 1968     | 0.1     | 0.2  | 0.2  | 0.1  |
| April 18, 1968     | 0.6     | 0.6  | 0.4  | 0.2  |
| April 25, 1968     | 1.8     | 1.0  | 0.6  | 0.1  |
| May 2, 1968        | 1.3     | 1.1  | 0.6  | 0.2  |
| May 23, 1968       | 5.5     | 5.7  | 5.0  | 4.6  |
| June 6, 1968       | 8.0     | 7.9  | 8.0  | 7.8  |
| June 13, 1968      | 12.5    | 12.8 | 12.2 | 12.3 |
| June 20, 1968      | 13.6    | 13.3 | 12.7 | 12.4 |
| June 27, 1968      | 11.8    | 11.6 | 11.1 | 11.1 |
| July 11, 1968      | 15.3    | 15.3 | 14.7 | 14.0 |
| July 18, 1968      | 15.3    | 14.1 | 14.2 | 14.1 |
| July 25, 1968      | 17.6    | 17.1 | 16.5 | 16.2 |
| August 1, 1968     | 13.0    | 12.9 | 12.6 | 12.3 |
| August 8, 1968     | 14.1    | 13.9 | 13.8 | 13.5 |
| August 15, 1968    | 12.8    | 12.7 | 12.2 | 12.0 |
| August 22, 1968    | 11.0    | 10.9 | 10.7 | 10.4 |
| August 29, 1968    | 9.0     | 8.9  | 8.7  | 8.8  |
| October 10, 1968   | 0.1     | 0.1  | 0.1  | 0.3  |
| October 17, 1968   | 0.1     | 0.1  | 0.1  | 0.1  |
| October 24, 1968   | 0.0     | 0.0  | 0.0  | 0.0  |



TABLE 8

## SUMMARY OF POLLUTION SOURCES TO CHENA RIVER, 1968

| MILE  | SOURCE DESCRIPTION                                    | RAW<br>BOD <sup>1</sup><br>(ppm) | FLOW<br>(mgd) | BOD<br>OUT<br>(ppm) | LOAD<br>BOD/<br>DAY | % OF<br>TOTAL |
|-------|-------------------------------------------------------|----------------------------------|---------------|---------------------|---------------------|---------------|
| 0-5   | Miscellaneous dwellings                               | 300                              | 0.002         | 300                 | 5                   | 0.20          |
| 5     | College Utilities Corp.                               | 300                              | 0.17          | 30                  | 42                  | 1.70          |
| 6     | Noyes Slough                                          | 300                              | 0.06          | 200                 | 15                  | 0.62          |
| 9     | Fairbanks Sewage<br>Treatment Plant                   | 300                              | 1.30          | 100                 | 1100                | 45.00         |
| 9.5   | Industrial Air Products                               | 300 lbs. Carbide (inert)/month   |               |                     |                     |               |
| 10    | Fairbanks Water<br>Treatment Plant                    | 25 lbs./day Ferric Salts         |               |                     |                     |               |
| 10    | Fairbanks Power Plant<br>a. ashes<br>b. cooling water | 7 tons/day<br>7.2 mgd @ 50°F     |               |                     |                     |               |
| 11.5  | Graehl <sup>2</sup>                                   | 300                              | 0.006         | 300                 | 15                  | 0.62          |
| 12    | Hamilton Acres <sup>3</sup>                           | 300                              | 0.007         | 300                 | 15                  | 0.62          |
| 12    | Island Homes                                          | 300                              | 0.030         | 300                 | 75                  | 3.10          |
| 12.5  | Fort Wainwright-South                                 | 300                              | 1.030         | 100                 | 860                 | 35.00         |
| 16    | Fort Wainwright-North                                 | 300                              | 0.350         | 100                 | 292                 | 12.00         |
| 22    | Chena Slough                                          | 300                              | 0.060         | 200                 | 15                  | 0.62          |
| TOTAL |                                                       |                                  | 3.02          |                     | 2436                |               |

1. B.O.D. values are sanitary engineering estimates.
2. Forty Mile Avenue to 3rd Street; 1/2 block down 2nd street both directions from Forty Mile; 1/2 block down 3rd both directions from Forty Mile.
3. Down Hamilton Avenue from Nordale School with approximately 50 dwellings attached.

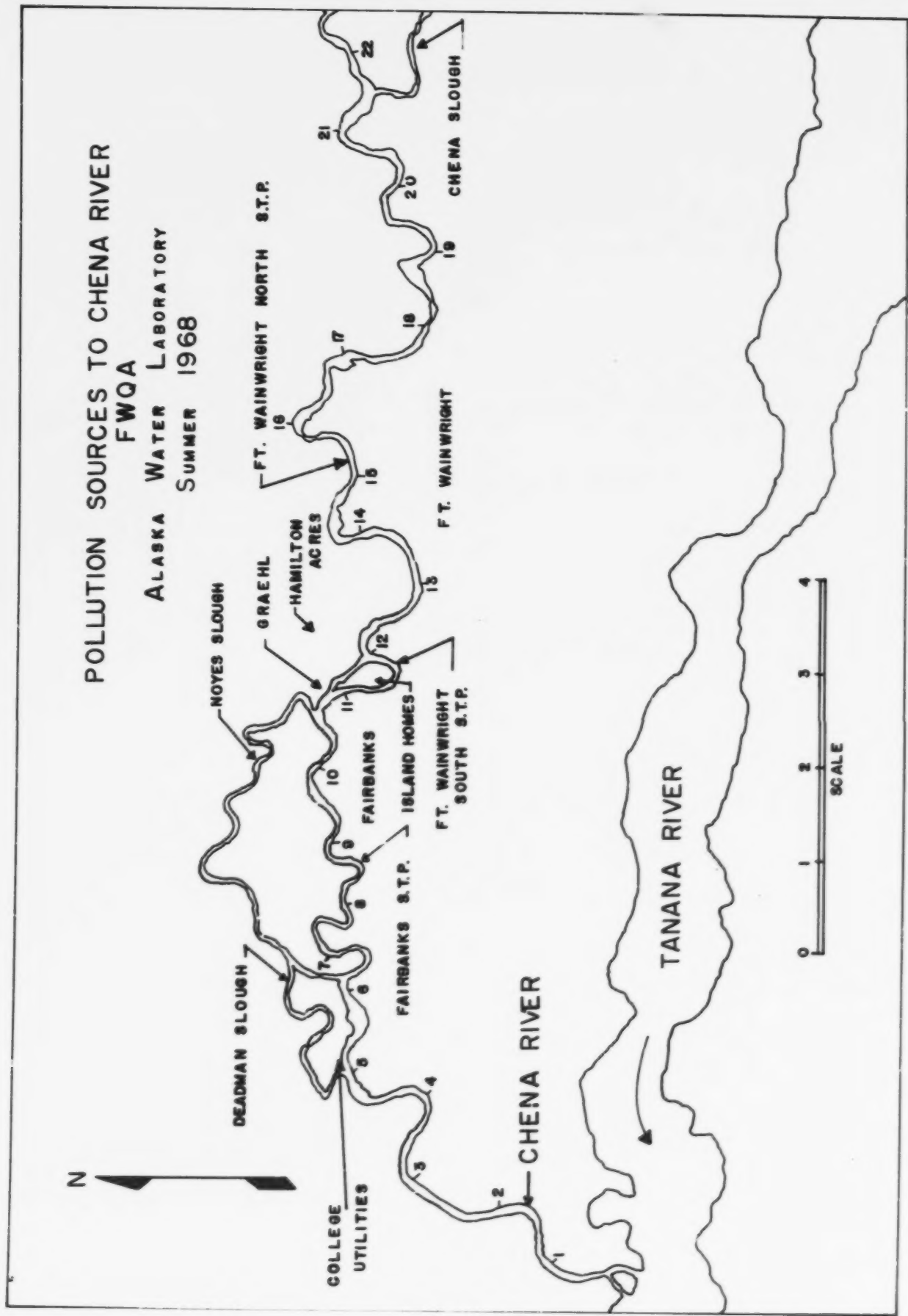


Figure 10

In addition to the domestic sewage wastes, there is a certain amount of industrial and thermal waste that is discharged into the river. Industrial Air Products, at mile 9.5, discharges approximately 3,000 pounds of carbide wastes per month as a waste product of their nitrogen liquefying process. The Municipal Utilities System water treatment plant releases 25 pounds per day of ferric salts when the filters are backwashed. The power plant discharges 7.2 million gallons per day of cooling water at 50°F and a large quantity of ashes from the plant eventually finds its way to the river.

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## SECTION IV

### FLOOD CONTROL

Flooding in the Chena River basin is not uncommon. As early as May 1905, high water from the spring thaw and runoff caused damage to the mining town of Fairbanks. Although discharge information is not available for this flood, the river elevation at the crest, May 5, 1905, is reported as 439.3 feet, making it the second highest known flood (USACE, 1967). Since that time, there have been five serious floods in the Fairbanks area--1911, 1930, 1937, 1948, and 1967. Discharge data is available only for the crests of the latest two floods, since a gaging station was not established until 1947 by the U.S. Geological Survey. The largest known flood occurred in August 1967, with a peak discharge of 74,400 cubic feet per second. Total damage to the Fairbanks area from this flood was estimated to be about \$75 million exclusive of damage to military installations (USACE, 1967). Only the 1930 and the 1967 floods occurred as a result of unusually heavy rainfall; the remaining floods were during the spring breakup period. Rapid snow melt, large snowfall in the upper basin, combined with jamming of the river by ice floes, usually causes these spring floods (Figure 11, Fairbanks Flood, 1967. Business district viewed from south edge of town).

Flood control measures were initiated in 1945 with the construction of a 3-mile long diversion dike across Chena Slough, easterly of Fairbanks, to prevent the Tanana River from entering the Chena River. A project to provide additional protection was authorized July 3, 1959. This project provided for an earth-fill dam, 1-1/2 miles long, across Chena River near mile 20, a diversion channel about 5.2 miles long from the Chena River to the Tanana River, and a levee 12 miles long, parallel to the diversion channel and the north bank of the Tanana River. Subsequent studies by the U.S. Army Corps of Engineers revealed that this project was inadequate because of the extensive economic development which had taken place after the pre-authorization studies were conducted.

These studies also indicated that storage upstream from the newly developed area would provide a practical solution to the flood problem, and protect considerably more property from flood damage.

Current flood control plans include the modification of the existing dike to extend downstream along the right banks of the Tanana River to the confluence of the Chena River, and upstream along the left bank of the Chena, 6 miles. Total length of the levee would be about 27 miles, with a maximum height of 18 feet and an average height of 9 feet.

The main flood control works will consist of two earth fill dams, one on the Chena River about 28 miles east of Fairbanks, and the other on the Little Chena River about 11 miles upstream from the confluence of the Chena River. Details of the proposed dams and their reservoir areas are



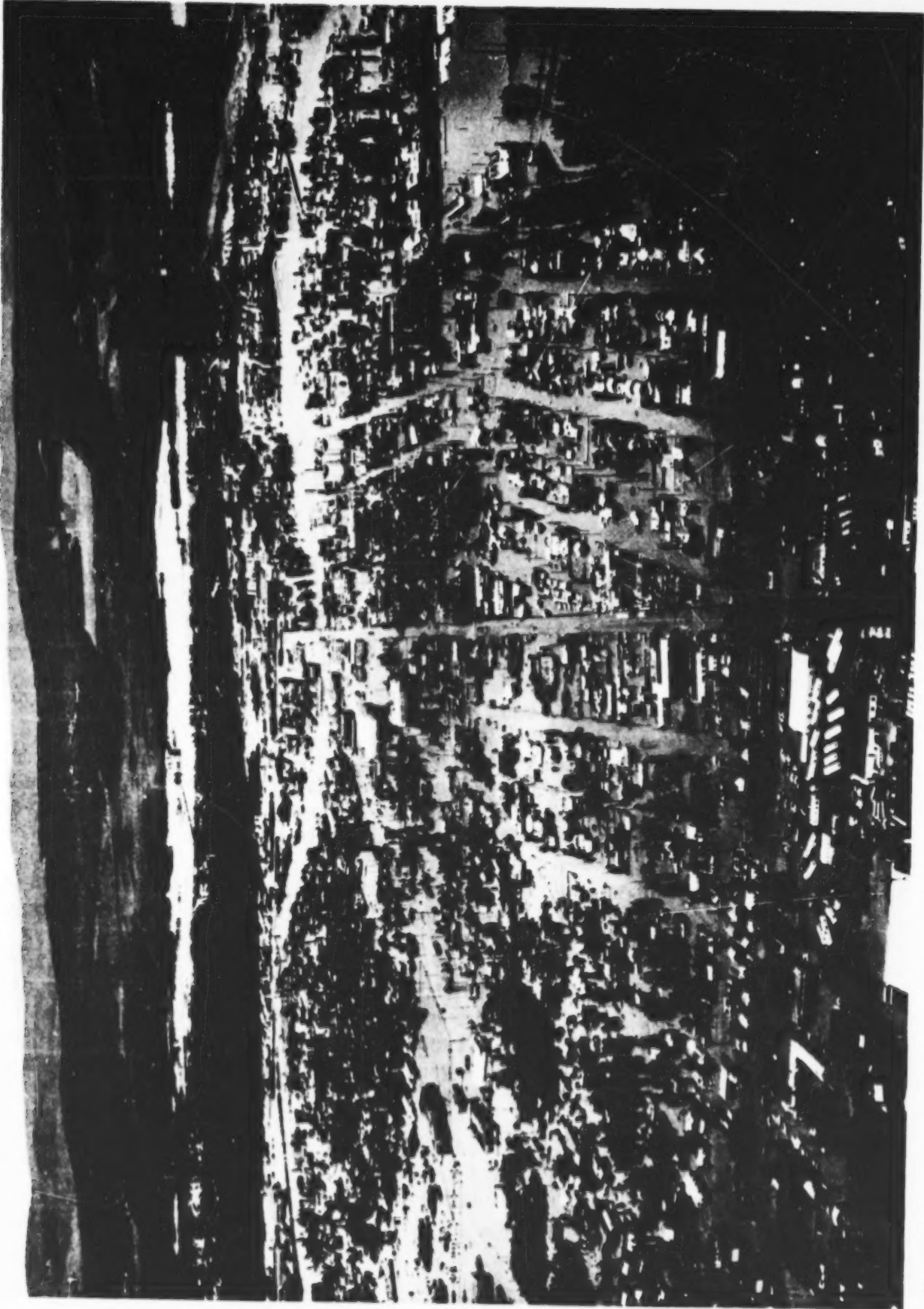


Figure 11. Fairbanks during 1967 Chena River Flood. View from the south end of Cushman Street looking north (Photo courtesy of U.S. Dept. of Interior, Bureau of Land Management)

shown in Figure 12. The Chena River work would include a gate-controlled ogee spillway, gate controlled outlet works, and have an active space capacity of 700,000 acre-feet. Details of the dam, spillway, and outlet works are shown in Figure 13.

Plans for the Chena dam include an experimental salmon incubation channel, relocation of the existing Chena Hot Springs road, and facilities for recreational use of the lake.

#### Reservoir Regulation

The recommended Little Chena River dam would be uncontrolled; therefore, all regulated control of flows would be carried out at the Chena River dam. The reservoir operation would be based primarily on the flood control requirement. However, flows would also be controlled to minimize ice jamming downstream of the dam. The operation plan requires that 400,000 acre-feet of storage would be available on October 1 of each year. Following October 1, a gradual release of flows would be maintained to provide storage space of 500,000 acre-feet by January 1. Between January 1 and the beginning of the snowmelt season, the reservoir would be regulated on a forecast basis. If normal runoff is expected, the reservoir would be drawn down to provide 565,000 acre-feet of storage. If, by June 15, above normal runoff is forecast, the reservoir would be drawn down to provide 700,000 acre-feet of storage. If below normal runoff is predicted, 500,000 acre-feet of flood control storage would be maintained. The reservoir would be filled to the summer recreation pool elevation of 711 MSL by June 15, leaving 400,000 acre-feet of emergency flood control storage. During the summer (June 15 to October 1), the reservoir would be operated to control summer rain floods to a maximum of 12,000 cfs (bankfull capacity) through Fairbanks and maintain the pool as near elevation 711 as possible. Minimum release from the reservoir for mosquito control and protection of the fish and wildlife resources during the period from June 15 to October 1, would be 800 cfs and during the period from October 1 to June 15, would be 300 cfs.

#### Recreational Development

Initially, two general recreation areas would be provided to the Chena River reservoir. Facilities for camping, picnicking, boat launching, swimming, and associated utilities and access roads are included in the overall plan for recreation. Additional boat launching facilities, parking areas and sanitary facilities would be provided within the framework of a reservoir zoning plan to minimize conflict with general recreation use. Additional future facilities are anticipated to be constructed at the 20th, 40th, and 60th year of project life.

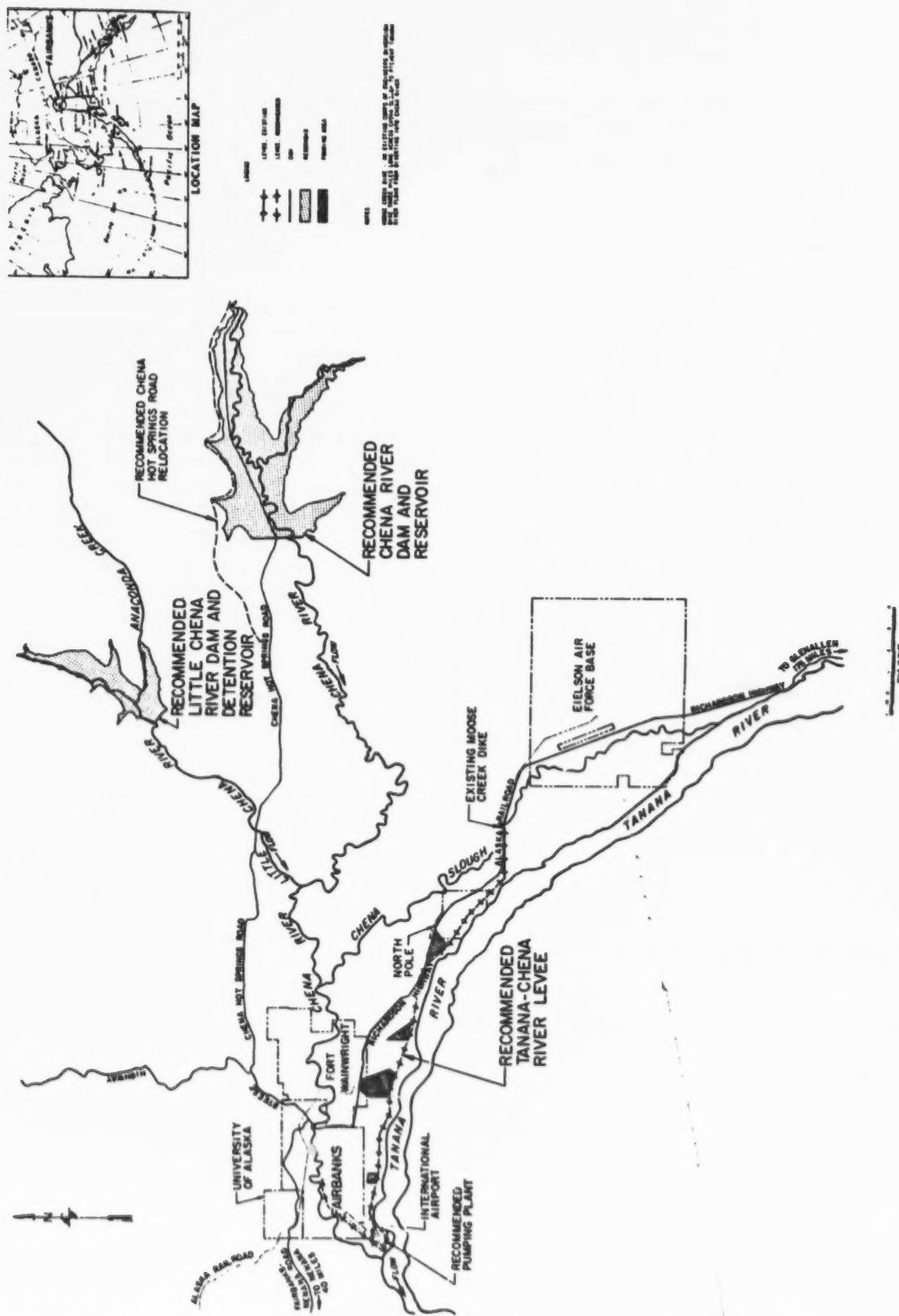


Figure 12. Proposed Chena River Flood Control Project, U.S. Army Corps of Engineers

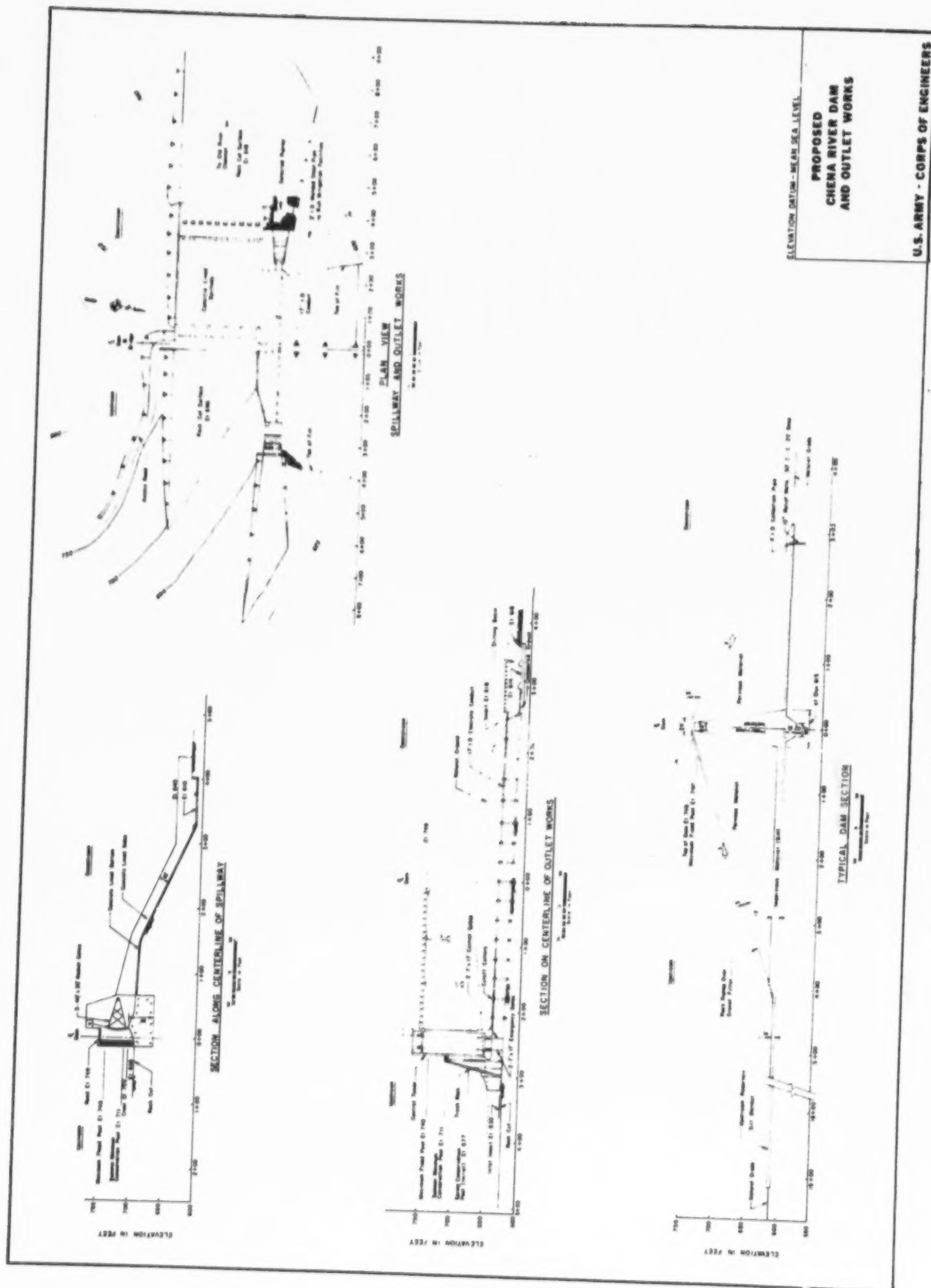


Figure 13

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## SECTION V

### CHEMISTRY OF THE CHENA RIVER

The limnology of a subarctic stream, such as the Chena River, is very different from the rivers of lower latitudes. During the winter, subarctic rivers have greatly extended periods of ice cover, are supplied only by groundwater and receive extremely low solar radiation. In the summer, they remain cool, drain large areas of muskeg, and are subjected to long periods of solar radiation. These factors greatly influence the chemistry and productivity of the stream.

Because of the ice cover in the winter, reaeration rates are relatively low. In addition, during this time, low insolation, combined with low temperatures, affects both the photosynthetic and respiration rates. For these reasons, chemical and nutrient cycles are affected.

Samples were taken in plastic bottles, transported to the laboratory, and stored at  $-20^{\circ}\text{C}$  prior to analysis. During the winter, it was necessary to drill holes through the ice cover to collect samples. In all analyses, the samples were on a total rather than a dissolved basis. Dissolved oxygen, pH, conductivity, and alkalinity were determined immediately after sampling.

Iron, calcium, magnesium, potassium, sodium, copper and manganese were determined by atomic absorption spectroscopy. Calcium and magnesium were measured after addition of 1 percent by weight lanthanum to the solution to suppress interference from sulfate and phosphate. Silica was determined by the ammonium molybdate method of Rainwater and Thatcher (1960). Total and orthophosphate and nitrate were determined either by following Standard Methods (1965) or by FWPCA Interim Official Methods (1968). Other analyses were performed following Standard Methods (1965).

Measurement of pH was made electrometrically. Values were corrected to  $25^{\circ}\text{C}$ . Buffers used were commercially available preparations to standardize the equipment to a pH of 6.86 or 7.00. Measurements of total alkalinity were made by titration with 0.02 normal sulfuric acid to an end point of 4.60. Conductivity was measured with a conductivity bridge. Values were corrected to  $25^{\circ}\text{C}$ . Temperature was measured with a mercury-in-glass thermometer calibrated against a thermometer standardized at the National Bureau of Standards. Carbohydrate and protein were determined using a modification of the method of Strickland and Parsons (1963).

#### Nutrients

Perhaps the most significant chemical parameters that can be studied in

a river system are the nutrients. These constituents are important because they are used as inorganic or organic food materials for bacteria and phytoplankton, the lowest members and primary producers of the food chain. In general, nutrients are considered to be the organic and inorganic forms of nitrogen, phosphorus, and silicon. Nitrogen and phosphorus compounds are required in the metabolism of all producer organisms. Silicon is included primarily because of its use by diatoms in their cell-wall construction. Combined forms of these three principal elements are considered by Hutchinson (1957) to be the principal limiting nutrients for phytoplankton.

### The Silica Cycle

The limiting concentrations of silica vary, depending on the species of diatoms under study. For example, Lund (1954) found Asterionella to be limited by concentrations of the order of 0.5 milligrams of silica as  $\text{SiO}_2$  per liter, whereas, Chu (1942) found that Fragilaria crotonensis grew best at about 30 mg/l of silica. This concentration is harmful not only to certain green algae, but also to Asterionella. Examination of the existing evidence supports the hypothesis that the optimum concentration for most planktonic diatom species is of the order of a few mg/l or less. For the benthic species, the best concentration may be as high as 30 mg/l. The principal source of silica in river waters is from the chemical weathering of silicate rock. Hutchinson (1957), reports that mean igneous water contains about 10.3 mg/l of silica and sedimentary water 19.4 mg/l.

Examination of the data in Table 9 shows that silica concentrations in the Chena River generally increase as samples are taken farther downstream.

As might be expected, samples taken in the winter or late fall contain appreciably higher concentrations of silica than those samples taken in the summer. This can be explained through two processes. In summer, the large population of diatoms reduces the available silica concentrations. In addition, increased surface runoff during this period will also tend to lower the concentration. For example, on July 5, 1967, the concentration was significantly lower than it was in the following September. The lowest value measured in July was 2.9 mg/l at station 500. The stage was high during the summer of 1967, reaching peak flood conditions in mid-August. After mid-August, the weather was dry and the river fell rapidly. However, even during periods of high runoff, the silica concentration in the Chena is not low enough to be a limiting nutrient for most diatom production.

TABLE 9  
NUTRIENT ANALYSIS FOR CHENA RIVER IN MG/L

| DATE                          | STATIONS * |       |       |       |       |       |       |       |       |
|-------------------------------|------------|-------|-------|-------|-------|-------|-------|-------|-------|
|                               | 100        | 200   | 300   | 400   | 500   | 600   | 700   | 800   | 900   |
| NITRATE, NO <sub>3</sub> as N |            |       |       |       |       |       |       |       |       |
| May/9/67                      | 0.01       | 0.01  | 0.01  | --    | 0.01  | 0.01  | 0.01  | 0.01  | 0.01  |
| Jul/5/67                      | 0.14       | 0.13  | 0.13  | 0.11  | 0.12  | 0.09  | 0.15  | 0.16  | 0.21  |
| Sep/26/67                     | 0.17       | 0.20  | 0.22  | 0.18  | 0.20  | 0.20  | 0.28  | 0.21  | 0.27  |
| Apr/8/68                      | 0.14       | 0.14  | 0.13  | 0.13  | 0.13  | 0.12  | 0.15  | 0.25  | 0.34  |
| Sep/4/68                      | 0.04       | 0.05  | 0.04  | 0.08  | 0.15  | 0.08  | 0.10  | 0.09  | 0.06  |
| Dec/30/68                     | 0.08       | 0.08  | 0.09  | 0.13  | 0.11  | 0.12  | 0.19  | 0.32  | 0.39  |
| NITRITE, NO <sub>2</sub> as N |            |       |       |       |       |       |       |       |       |
| May/9/67                      | 0.47       | 0.44  | 0.52  | --    | 0.40  | 0.47  | 0.48  | 0.43  | 0.32  |
| Jul/5/67                      | 0.22       | 0.23  | 0.19  | 0.12  | 0.13  | 0.08  | 0.07  | 0.07  | 0.06  |
| Sep/26/67                     | 0.003      | 0.003 | 0.003 | 0.002 | 0.002 | 0.002 | 0.002 | 0.001 | 0.002 |
| Apr/8/68                      | 0.01       | 0.01  | 0.004 | 0.004 | 0.003 | 0.003 | 0.001 | 0.001 | 0.001 |
| Sep/4/68                      | 0.01       | 0.005 | 0.005 | 0.002 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 |
| Dec/30/68                     | 0.01       | 0.01  | 0.01  | 0.01  | 0.01  | 0.01  | 0.01  | 0.01  | 0.01  |
| AMMONIA, NH <sub>3</sub> as N |            |       |       |       |       |       |       |       |       |
| May/9/67                      | 1.52       | 1.52  | 1.52  | 1.42  | 1.39  | 1.23  | 1.30  | 1.30  | 1.27  |
| Jul/5/67                      | 0.26       | 0.23  | 0.25  | 0.33  | 0.34  | 0.23  | 0.21  | 0.18  | 0.22  |
| Sep/26/67                     | 0.28       | 0.25  | 0.42  | 0.16  | 0.10  | 0.10  | 0.08  | 0.06  | 0.02  |
| Apr/8/68                      | 0.78       | 0.78  | 0.66  | 0.42  | 0.40  | 0.25  | 0.08  | 0.11  | 0.10  |
| Sep/4/68                      | 0.24       | 0.16  | 0.14  | 0.10  | 0.23  | 0.12  | 0.09  | 0.15  | 0.09  |
| Dec/30/68                     | 1.54       | 1.60  | 1.92  | 0.48  | 0.79  | 0.43  | 0.09  | 0.10  | 0.11  |

\*See Table 2

TABLE 9 Cont.

| DATE      | STATIONS                   |      |      |      |      |      |      |      |      |
|-----------|----------------------------|------|------|------|------|------|------|------|------|
|           | 100                        | 200  | 300  | 400  | 500  | 600  | 700  | 800  | 900  |
|           | PHOSPHATE, TOTAL AS $PO_4$ |      |      |      |      |      |      |      |      |
| May/9/67  | 0.02                       | 0.05 | 0.02 | -    | 0.03 | 0.03 | 0.03 | 0.04 | 0.01 |
| Jul/5/67  | 0.10                       | 0.15 | 0.12 | 0.13 | 0.15 | 0.10 | 0.28 | 0.24 | 0.26 |
| Sep/26/67 | 0.08                       | 0.00 | 0.00 | 0.00 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 |
| Apr/8/68  | 0.68                       | 0.66 | 0.51 | 0.20 | 0.20 | 0.10 | 0.08 | 0.08 | 0.06 |
| Sep/4/68  | 0.22                       | 0.22 | 0.22 | 0.17 | 0.17 | 0.10 | 0.14 | 0.08 | 0.07 |
| Dec/30/68 | 0.36                       | 0.48 | 1.07 | 0.27 | 0.24 | 0.10 | 0.04 | 0.06 | 0.04 |
|           | PHOSPHATE, ORTHO AS $PO_4$ |      |      |      |      |      |      |      |      |
| Jul/5/67  | 0.07                       |      | 0.03 | 0.02 |      | 0.02 | 0.01 | 0.02 | 0.07 |
| Sep/26/67 | 0.00                       | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Apr/8/68  | 0.35                       | 0.35 | 0.28 | 0.13 | 0.09 | 0.07 | 0.02 | 0.03 | 0.02 |
| Sep/4/68  | 0.07                       | 0.07 | 0.07 | 0.08 | 0.04 | 0.06 | 0.04 | 0.03 | 0.01 |
| Dec/30/68 |                            | 0.36 | 0.63 |      | 0.18 | 0.08 | 0.02 | 0.01 | 0.02 |
|           | SILICA, AS $SiO_2$         |      |      |      |      |      |      |      |      |
| Jul/5/67  | 7.9                        | 7.7  | 8.0  | 6.6  | 2.9  | 5.9  | 5.7  | 3.6  | 4.4  |
| Sep/26/67 | 13.3                       | 13.0 | 13.3 | 11.5 | 10.4 | 9.7  | 8.7  | 8.6  | 8.4  |
| Apr/8/68  | 16.9                       | 16.4 | 16.3 | 13.7 | 10.3 | 10.3 | 8.4  | 8.5  | 8.2  |
| Sep/4/68  | 9.5                        | 9.9  | 9.3  | 9.3  | 8.6  | 7.6  | 7.4  | 7.3  | 7.2  |
| Dec/30/68 | 10.2                       | 8.6  | 12.6 | 7.2  | 6.4  | 5.5  | 6.5  | 5.1  | 4.9  |

## The Nitrogen Cycle

The nitrogen cycle is one of the most interesting and important nutrient cycles. However, it is extremely difficult to study because of the difficulty of analysis of the many types of compounds which can act as sources of nitrogen for phytoplankton and bacteria.

The principal source of nitrogen compounds in water is from fixation of atmospheric nitrogen, both in the flowing streams and from drainage of soils in which fixation occurs. Bacteria performing fixation are present not only in the mud/water interface, but may be attached to roots of plants in the environment near the shore. Also, mycorrhiza on alder roots may be a significant contribution. Blue-green algae are also important nitrogen-fixing organisms, such as the case of the genus *Anabaena* (Hutchinson, 1957). This fixation of nitrogen results in compounds which are available for absorption by bacteria, when they excrete ammonia, nitrite, and nitrate. The resultant inorganic forms of nitrogen are then available as food for photoplankton. Some bacteria are capable of denitrification; that is, the reduction of nitrate completely to nitrogen gas. One might expect, under ice cover in the winter, to find that nitrogen compounds are in a more reduced state than they would be in the summer. This could be associated with the reduction in the dissolved oxygen levels in the lower reaches of the Chena River. Table 8 shows that in April, May and December of 1967 and 1968, the ammonia levels were high. In July and September, however, ammonia concentrations were low. As nitrite is an intermediate reduced form of nitrogen, one might expect it to be higher in the winter than in the summer; however, nitrite does not show any regular pattern. Peaks in the nitrite appeared to occur in May and July of 1967; however, this may have been because surface water was introduced during this period of very high runoff. Although concentrations of nitrite on December 30, 1968, appeared slightly higher than concentrations of September 4 or April 8, 1968, these changes were very small and are not significant.

In its more highly oxidized state, nitrate might be expected to show lower concentrations in the winter months than in the summer; however, the available data do not substantiate this hypothesis adequately (Table 8). It is interesting to note that in almost all measurements, samples taken from the upper Chena River--that is, stations 600 through 900--showed significantly higher nitrate than did the lower stations. This is especially evident from the samples collected on December 30, 1968, in which the concentration at station 900 was 0.39 mg/l and at station 100 was 0.08 mg/l. This might be the result of the dissolved oxygen regime in the lower Chena River. At the same time, ammonia concentrations ranged from 0.11 at station 900 to 1.54 mg/l at station 100. Nitrite appeared to be uniformly distributed throughout the river in equilibrium with nitrate and ammonia.

## The Phosphorus Cycle

According to Hutchinson (1967), phosphorus is likely to be the most ecologically important element of all those present in living organisms,



primarily because the ratio of phosphorus to other elements in organisms is considerably greater than the ratio in the primary sources; i.e., water and muds. Therefore, phosphorus may be much more likely to limit the productivity of the river than any other material. Sources of phosphate in rivers include introduction from groundwater in areas of igneous activity, leaching of soils, and from sewage effluents. Of the many possible forms of soluble phosphorus compounds, usually orthophosphate is the only one likely to be of importance in the aquatic environment.

Dissolved inorganic phosphate is the principal form of phosphorus taken up by phytoplankton, although some may be able to absorb dissolved organic phosphate compounds. Bacteria convert both dissolved organic phosphorus and particulate phosphorus compounds into dissolved inorganic phosphate. Some particulate inorganic phosphate may be found in water. Usually this is a small amount and may actually be soluble phosphates adsorbed into detrital particles.

Our analysis was limited to total phosphate and orthophosphate. This gave a measure of the amount of phosphate generally available for phytoplankton production, as well as a measure of the total amount of phosphate present in the aquatic environment. Orthophosphate compounds are used extensively in detergents; therefore, a higher amount of orthophosphate in the lower reaches of the river below the sewage outfall would be expected (Table 9). At virtually all sampling times, the orthophosphate concentrations at the lower stations are significantly higher than at the upper stations.

Total phosphate data taken in 1968 seems to substantiate the hypothesis set down for orthophosphate. Samplings between April 8 and September 4, 1968, show that there is an increase in total phosphate in the lower reaches by a factor of 3 to 10. This is explained, not only by the significant introduction of phosphate materials by sewage treatment plants, but also by the evaporative concentration of nutrients in the lower river.

### Trace Metals

Trace metals are important constituents for the biota of natural streams. For example, the freshwater members of the phylum mollusca, the families bivalvia and gastropoda, must have sufficient calcium for the formation of their calcareous shells.

Hutchinson (1957) gives the mean equivalent percentages of cations and anions in certain important natural waters. Values for the mean river, taken from Clark (1924), are: sodium, 15.7 percent; potassium, 3.4 percent; magnesium, 17.4 percent; and calcium, 63.5 percent. Values for equivalent percentages of major cations in the Chena River at all nine stations for winter and summer 1967-1968 will be found in Table 10. Concentrations of all metals determined are listed in Table 11 in milligrams per liter.

TABLE 10  
EQUIVALENT PERCENTAGES OF MAJOR CATIONS, CHENA RIVER

| <u>CALCIUM</u> |                       |                       |                        | <u>MAGNESIUM</u> |                       |                       |                        |
|----------------|-----------------------|-----------------------|------------------------|------------------|-----------------------|-----------------------|------------------------|
| <u>Station</u> | <u>Jul 5<br/>1967</u> | <u>Apr 8<br/>1968</u> | <u>Dec 30<br/>1968</u> | <u>Station</u>   | <u>Jul 5<br/>1967</u> | <u>Apr 8<br/>1968</u> | <u>Dec 30<br/>1968</u> |
| 100            | 67.0                  | 62.7                  | 64.0                   | 100              | 23.0                  | 25.6                  | 24.8                   |
| 200            | 68.5                  | 66.0                  | 61.2                   | 200              | 22.8                  | 20.2                  | 26.0                   |
| 300            | 67.3                  | 63.5                  | 61.6                   | 300              | 23.2                  | 21.3                  | 25.7                   |
| 400            | 67.5                  | 67.0                  | 65.2                   | 400              | 24.2                  | 21.8                  | 25.6                   |
| 500            | 67.1                  | 70.0                  | 65.0                   | 500              | 25.2                  | 21.5                  | 24.8                   |
| 600            | 67.2                  | 75.5                  | 66.1                   | 600              | 24.4                  | 15.1                  | 25.5                   |
| 700            | 67.6                  | 72.2                  | 68.0                   | 700              | 24.8                  | 18.3                  | 24.6                   |
| 800            | 68.5                  | 69.0                  | 68.4                   | 800              | 23.0                  | 20.6                  | 24.8                   |
| 900            | 69.5                  | 76.5                  | 69.4                   | 900              | 23.1                  | 16.3                  | 22.3                   |

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| <u>SODIUM</u>  |                       |                       |                        | <u>POTASSIUM</u> |                       |                       |                        |
|----------------|-----------------------|-----------------------|------------------------|------------------|-----------------------|-----------------------|------------------------|
| <u>Station</u> | <u>Jul 5<br/>1967</u> | <u>Apr 8<br/>1968</u> | <u>Dec 30<br/>1968</u> | <u>Station</u>   | <u>Jul 5<br/>1967</u> | <u>Apr 8<br/>1968</u> | <u>Dec 30<br/>1968</u> |
| 100            | 5.8                   | 8.7                   | 7.1                    | 100              | 3.4                   | 2.9                   | 4.2                    |
| 200            | 5.6                   | 10.9                  | 8.1                    | 200              | 3.3                   | 2.9                   | 4.3                    |
| 300            | 5.5                   | 11.7                  | 8.3                    | 300              | 4.1                   | 2.9                   | 4.3                    |
| 400            | 4.9                   | 8.6                   | 5.4                    | 400              | 3.2                   | 2.9                   | 3.6                    |
| 500            | 4.5                   | 6.0                   | 6.0                    | 500              | 3.1                   | 2.7                   | 2.7                    |
| 600            | 5.4                   | 6.3                   | 2.2                    | 600              | 2.9                   | 2.9                   | 1.2                    |
| 700            | 4.4                   | 6.5                   | 4.9                    | 700              | 3.1                   | 1.9                   | 2.0                    |
| 800            | 5.3                   | 8.6                   | 4.8                    | 800              | 3.3                   | 1.7                   | 1.9                    |
| 900            | 4.2                   | 5.4                   | 5.1                    | 900              | 3.2                   | 1.8                   | 2.0                    |

equivalent percentages of major cations in the Chena River at all nine stations for winter and summer 1967-68 will be found in Table 10. Concentrations of all metals determined are listed in Table 11 in milligrams per liter.

It is interesting to note that the equivalent percentages for calcium and magnesium are fairly uniform at most of the stations during all three of the time periods listed in Table 10. The range for calcium was from 61.2 percent at station 200 on December 30, 1968, to 76.5 percent at station 900 on April 8, to 26.0 percent at station 200 on December 30. Sodium and potassium values, on the other hand, seem to range more widely. For sodium, the value was 2.2 percent at station 600 on December 30, 10.9 percent on April 8 at station 200, and 4.2 percent at station 900 on July 20, 1967. The relatively low proportions of sodium and potassium in the river indicate that the source of these cations is principally from sedimentary or metamorphic material rather than from igneous, which tends to contribute to the sodium concentrations. Trace metal concentrations at all nine stations in the river for the dates of May 9, July 5, September 25, 1967, April 8, September 4, and December 30, 1968, will be found in Table 10. In addition to calcium, magnesium, potassium, and sodium, the principal cations, measurements of iron, manganese, and copper were made.

In general, copper concentrations were very close to the limits of detectability with the available instruments. Copper, at the levels found, is not an important element in water quality at this time (Table 11). Manganese concentrations are also low and, in general, do not contribute significantly to the cation load of the river. Other trace metals, such as molybdenum, chromium, and nickel, frequently found in waters which have been used for cooling purposes in boilers or which are considered important to the metabolism of the organisms in the river system were not investigated.

#### Chemical Oxygen Demand

Many fresh waters of Alaska, both surface and groundwater, have a very high organic content. Early in the study of the Chena River, an attempt was made to establish the level of organic material present and how it changed as the river progressed through an area into which raw and partially treated sewage was introduced. In addition, observations were made of the changes in the chemical oxygen demand during the spring runoff period and during breakup of the ice surface. During this period, much of the surface water had a chance to soak into the upper layers of moss and detritus in the watershed and extract organic materials which were then carried into the river itself. This phenomenon would account for high levels of chemical oxygen demand during this period. In addition, it would be expected that water from the river below areas of sewage effluents would have a higher chemical oxygen demand than waters above these areas.

TABLE 11  
TRACE METALS-CHENA RIVER-MG/L

| Station        | May 9<br>1967 | Jul 5<br>1967 | Sep 26<br>1967 | Apr 8<br>1968 | Sep 4<br>1968 | Dec 30<br>1968 |
|----------------|---------------|---------------|----------------|---------------|---------------|----------------|
| <u>CALCIUM</u> |               |               |                |               |               |                |
| 100            | ---           | 25.6          | ---            | 31.5          | ---           | 35.0           |
| 200            | ---           | 26.5          | ---            | 32.1          | ---           | 29.5           |
| 300            | ---           | 26.5          | ---            | 29.4          | ---           | 28.5           |
| 400            | ---           | 24.7          | ---            | 27.3          | ---           | 30.4           |
| 500            | ---           | 22.9          | ---            | 22.5          | ---           | 23.3           |
| 600            | ---           | 23.05         | ---            | 23.1          | ---           | 21.9           |
| 700            | ---           | 23.4          | ---            | 26.4          | ---           | 23.0           |
| 800            | ---           | 22.2          | ---            | 28.8          | ---           | 25.1           |
| 900            | ---           | 23.4          | ---            | 29.7          | ---           | 25.6           |
| <u>SODIUM</u>  |               |               |                |               |               |                |
| 100            | 1.00          | 2.5           | 2.88           | 5.0           | 2.55          | 4.45           |
| 200            | 1.20          | 2.5           | 2.32           | 6.1           | 4.63          | 4.45           |
| 300            | 1.30          | 2.45          | 2.25           | 6.3           | 2.50          | 4.40           |
| 400            | 1.20          | 2.00          | 1.95           | 4.0           | 2.93          | 2.90           |
| 500            | 1.06          | 1.75          | 2.25           | 2.2           | 1.95          | 2.45           |
| 600            | 1.24          | 2.10          | 1.78           | 2.2           | 1.76          | 0.85           |
| 700            | 1.26          | 1.75          | 1.92           | 2.7           | 2.10          | 1.90           |
| 800            | 1.20          | 1.95          | 1.57           | 4.1           | 1.83          | 2.05           |
| 900            | 1.30          | 1.60          | 1.92           | 2.4           | 1.76          | 2.15           |
| <u>IRON</u>    |               |               |                |               |               |                |
| 100            | 0.57          | 0.81          | 0.75           | 0.28          | 0.65          | 2.15           |
| 200            | 0.45          | 0.80          | 0.79           | 0.32          | 0.62          | 2.15           |
| 300            | 0.55          | 0.67          | 0.75           | 0.24          | 0.60          | 2.26           |
| 400            | 0.55          | 0.64          | 0.75           | 0.28          | 0.60          | ---            |
| 500            | 0.50          | 0.61          | 0.68           | 0.40          | 0.60          | 2.79           |
| 600            | 0.20          | 0.52          | 0.64           | 0.28          | 0.45          | 0.58           |
| 700            | 0.29          | 0.19          | 0.27           | 0.06          | 0.17          | 0.12           |
| 800            | 0.29          | 0.095         | 0.13           | 0.00          | 0.20          | 0.10           |
| 900            | 0.18          | 0.03          | 0.09           | 0.00          | 0.13          | 0.10           |
| <u>COPPER</u>  |               |               |                |               |               |                |
| 100            | 0.008         | 0.005         | 0.00           | 0.00          | ---           | 0.02           |
| 200            | 0.008         | 0.002         | 0.037          | 0.00          | ---           | 0.02           |
| 300            | 0.008         | 0.010         | 0.010          | 0.00          | ---           | 0.02           |
| 400            | 0.008         | 0.011         | 0.00           | 0.00          | ---           | 0.02           |
| 500            | 0.011         | 0.005         | 0.005          | 0.00          | ---           | 0.02           |
| 600            | 0.008         | 0.005         | 0.15           | 0.00          | ---           | 0.02           |
| 700            | 0.010         | 0.010         | 0.030          | 0.00          | ---           | 0.02           |
| 800            | 0.018         | 0.011         | 0.016          | 0.00          | ---           | 0.02           |
| 900            | 0.018         | 0.010         | 0.092          | 0.00          | ---           | 0.02           |

TABLE 11 Cont.

| Station          | May 9<br>1967 | Jul 5<br>1967 | Sep 26<br>1967 | Apr 8<br>1968 | Sep 4<br>1968 | Dec 30<br>1968 |
|------------------|---------------|---------------|----------------|---------------|---------------|----------------|
| <u>MAGNESIUM</u> |               |               |                |               |               |                |
| 100              | 5.13          | 5.35          | --             | 7.8           | 5.9           | 8.25           |
| 200              | 5.37          | 6.40          | --             | 6.0           | 6.1           | 7.60           |
| 300              | 5.14          | 5.55          | --             | 6.0           | 5.7           | 7.22           |
| 400              | 5.37          | 5.40          | --             | 5.4           | 5.6           | 7.22           |
| 500              | 5.37          | 5.25          | --             | 4.2           | 5.1           | 5.82           |
| 600              | 6.25          | 5.80          | --             | 2.8           | 4.8           | 5.12           |
| 700              | 5.88          | 5.20          | --             | 4.0           | 4.7           | 5.05           |
| 800              | 6.13          | 4.51          | --             | 5.2           | 4.7           | 5.55           |
| 900              | 6.00          | 4.72          | --             | 3.8           | 4.6           | 5.24           |
| <u>POTASSIUM</u> |               |               |                |               |               |                |
| 100              | 1.40          | 1.50          | 1.50           | 1.65          | 1.40          | 2.62           |
| 200              | 1.55          | 1.46          | 1.58           | 1.65          | 1.45          | 2.36           |
| 300              | 1.60          | 1.85          | 1.48           | 1.55          | 1.20          | 2.28           |
| 400              | 1.62          | 1.35          | 1.28           | 1.35          | 1.30          | 1.91           |
| 500              | 1.52          | 1.22          | 1.40           | 1.00          | 1.08          | 1.02           |
| 600              | 1.25          | 1.15          | 1.19           | 1.00          | 1.08          | 0.40           |
| 700              | 1.55          | 1.22          | 1.23           | 0.80          | 1.05          | 0.82           |
| 800              | 1.48          | 1.22          | 1.00           | 0.80          | 1.09          | 0.80           |
| 900              | 0.70          | 1.22          | 1.45           | 0.80          | 1.10          | 0.83           |
| <u>MANGANESE</u> |               |               |                |               |               |                |
| 100              | 0.10          | 0.085         | 0.18           | --            | --            | --             |
| 200              | 0.06          | 0.070         | 0.21           | 0.00          | --            | --             |
| 300              | 0.085         | 0.050         | 0.17           | 0.16          | --            | --             |
| 400              | 0.075         | 0.050         | 0.13           | 0.20          | --            | --             |
| 500              | 0.080         | 0.050         | 0.085          | 0.11          | --            | --             |
| 600              | 0.050         | 0.070         | 0.070          | 0.10          | --            | --             |
| 700              | 0.065         | 0.032         | 0.023          | 0.01          | --            | --             |
| 800              | 0.075         | 0.020         | 0.010          | 0.02          | --            | --             |
| 900              | 0.080         | 0.020         | 0.007          | 0.01          | --            | --             |



To better understand these relationships, a study was designed to sample the river at weekly intervals from March 7, 1967, to May 18, 1967, determining the chemical oxygen demand values in four stations (Table 12). Station 100 is below most areas of influence from sewage outfalls. Station 200 is a mid-station below the sewage treatment effluent from Fairbanks, but above sewage fallout from the College area from the University of Alaska. Station 300 is above the majority of sewage effluents from the Fairbanks area, but is below that from Fort Wainwright, where two primary treatment plants are located. Station 400 is above all waste treatment facilities and would serve as a control (Figure 2).

Station 400 presented some difficulties in sampling, principally because it is located in an area which is used for disposal of automobile bodies, and the rusting automobiles cause a high iron concentration in the river. This may account for the high levels noted on April 11 and 18, 1967. However, during most periods, the samples were clear and gave acceptable results.

The chemical oxygen demand levels do increase as the river runs downstream. They are indicative of the increased level of pollution with organic materials as it flows through the municipal areas. The most striking changes in these curves are those which occur during the spring breakup, when the level of chemical oxygen demand increases at all stations within a few days, in most cases, from 10-20 mg/l to 40-50 mg/l. The level after breakup, as the runoff water volume decreases, then goes down to values similar to those found in the winter. Values for July 5, 1967, for example, gave levels of chemical oxygen demand at station 100 of 12.2 mg/l, station 200 of 15.8 mg/l, station 300 of 15.8 mg/l, and station 400 of 15.6 mg/l.

In the winter of 1967-68, weekly samples were collected for the determination of total organic carbon, total carbohydrate and protein (Strickland and Parsons, 1965). Analysis of the data presented in Tables 13, 14, and 15, for samples collected weekly from all nine stations, shows the same trends as those observed in the chemical oxygen demand. Concentrations were at a minimum during the time from January to April. During April, all stations increased, probably resulting from the surface drainage runoff conditions, and again declined following the high water in May. Since the main interest lay in determining what was causing apparent anomalies under winter conditions in the river, samples were collected only during that period of the year. It is interesting to note that at many stations there is a peak in carbohydrate concentration during the months of December and early January, and that this peak levels off in February, the values remaining relatively constant throughout until May. In May, carbohydrates increase rapidly in areas of pollution; however, this is not consistent. This inconsistency also holds true for proteins.

### Dissolved Oxygen

The dissolved oxygen data presented in Table 16 was collected from the Chena River, October 1967 to May 1969. Values for both the upper and

TABLE 12  
CHEMICAL OXYGEN DEMAND VALUES IN MG/L

| Date      | STATIONS |      |      |      |        |       |       |       |       |
|-----------|----------|------|------|------|--------|-------|-------|-------|-------|
|           | 100      | 200  | 300  | 400  | 500    | 600   | 700   | 800   | 900   |
| Mar/7/67  | 25.2     | 16.3 | 12.3 | 8.5  | -----* | ----- | ----- | ----- | ----- |
| Mar/14/67 | 13.6     | 14.2 | 11.0 | 9.8  | -----  | ----- | ----- | ----- | ----- |
| Mar/21/67 | 14.8     | 14.6 | 8.9  | 7.8  | -----  | ----- | ----- | ----- | ----- |
| Mar/28/67 | 15.1     | 14.5 | 11.4 | 9.9  | -----  | ----- | ----- | ----- | ----- |
| Apr/3/67  | 14.7     | 15.7 | 11.6 | 9.8  | -----  | ----- | ----- | ----- | ----- |
| Apr/11/67 | 13.8     | 15.7 | 12.4 | 17.6 | -----  | ----- | ----- | ----- | ----- |
| Apr/18/67 | 12.7     | 15.3 | 10.8 | 13.8 | -----  | ----- | ----- | ----- | ----- |
| Apr/25/67 | 14.8     | 15.7 | 12.1 | 7.8  | -----  | ----- | ----- | ----- | ----- |
| May/2/67  | 17.6     | 15.2 | 16.7 | 10.5 | -----  | ----- | ----- | ----- | ----- |
| May/9/67  | 47.2     | 44.9 | 46.3 | 43.5 | 43.4   | 43.5  | 40.3  | 46.6  | 38.0  |
| May/17/67 | 43.5     | 42.1 | 40.8 | 40.9 | -----  | ----- | ----- | ----- | ----- |
| May/24/67 | 43.4     | 41.6 | 40.1 | 40.5 | -----  | ----- | ----- | ----- | ----- |
| Dec/30/68 | 12.1     | 13.1 | 21.0 | 34.4 | 12.9   | 12.5  | 13.3  | 7.9   | 12.7  |

\*-----Indicates that no sample was collected on this date

TABLE 13  
CARBON VALUES-CHENA RIVER-MG/L\*

| Date      | STATIONS |      |      |      |      |      |      |      |      |
|-----------|----------|------|------|------|------|------|------|------|------|
|           | 100      | 200  | 300  | 400  | 500  | 600  | 700  | 800  | 900  |
| Dec/15/67 | 26.6     | 26.5 | 26.4 | 25.4 | 22.1 | 20.2 | 18.8 | 19.7 | 18.2 |
| Dec/22/67 | 26.5     | 26.9 | 25.3 | 24.3 | 22.4 | --** | 21.2 | 19.3 | 16.4 |
| Jan/4/68  | 27.8     | 27.7 | 26.3 | 24.8 | 21.9 | 20.6 | 19.5 | 20.1 | 19.2 |
| Jan/11/68 | 23.7     | 27.1 | 25.1 | 25.0 | 19.4 | 18.2 | 19.9 | 19.2 | 16.8 |
| Jan/18/68 | 30.2     | 31.5 | 29.2 | 26.8 | --   | 22.4 | 21.8 | 21.0 | 20.8 |
| Jan/25/68 | 32.5     | 30.1 | 28.8 | 26.7 | 24.7 | 22.2 | 19.4 | 19.8 | --   |
| Feb/1/68  | 32.0     | --   | 30.0 | --   | --   | 21.5 | --   | 21.7 | --   |
| Feb/7/68  | 32.7     | 32.8 | 30.2 | 27.4 | 27.8 | 24.5 | --   | 22.8 | 21.8 |
| Feb/15/68 | 32.0     | 33.4 | 29.1 | 26.6 | 25.0 | 21.5 | 22.1 | 21.9 | 20.1 |
| Feb/29/68 | 30.0     | 34.3 | 29.0 | 28.8 | 25.9 | 22.7 | 22.3 | 22.8 | 19.8 |
| Mar/8/68  | 31.9     | 31.0 | 30.1 | 26.3 | 26.4 | 22.7 | 21.1 | 22.4 | 20.5 |
| Mar/14/68 | 30.0     | 25.3 | 27.6 | 26.0 | 24.4 | 22.6 | 20.2 | 20.8 | 20.2 |
| Mar/21/68 | 32.7     | 34.0 | 32.3 | 30.0 | 26.5 | 25.7 | 21.9 | 23.5 | 21.3 |
| Mar/28/68 | 28.4     | 32.5 | 29.2 | 28.6 | 24.8 | 22.2 | 21.8 | 23.5 | 23.2 |
| Apr/11/68 | --       | --   | --   | 27.9 | 21.8 | 23.4 | 22.2 | 23.8 | 19.1 |
| Apr/18/68 | 31.0     | 29.4 | 29.2 | 27.3 | 21.5 | 21.5 | 20.1 | 22.8 | 20.7 |
| Apr/25/68 | 32.6     | 30.0 | 29.1 | 32.9 | 23.2 | 20.3 | 22.1 | 21.9 | 18.4 |
| May/5/68  | 27.5     | 27.8 | 26.7 | 24.2 | 25.3 | 21.0 | 32.3 | 26.2 | 22.3 |
| May/9/68  | 31.2     | 28.7 | 31.5 | 31.1 | 31.7 | 28.5 | 27.9 | 28.7 | --   |
| May/16/68 | 27.0     | 27.8 | 28.1 | 26.3 | 26.0 | 25.2 | 23.3 | 26.0 | --   |
| May/23/68 | 25.4     | 24.9 | 24.8 | 24.4 | 21.7 | 23.8 | 21.0 | 20.6 | --   |

\*Total Organic Carbon (T.O.C.)

\*\*--Indicates that no sample was collected on this date

2 OF 2  
PB  
197857

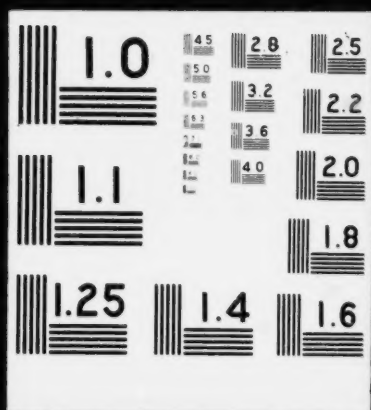


TABLE 14  
CARBOHYDRATE VALUES-CHENA RIVER-MG/1

| Date      | STATIONS |       |       |       |       |       |       |       |      |
|-----------|----------|-------|-------|-------|-------|-------|-------|-------|------|
|           | 100      | 200   | 300   | 400   | 500   | 600   | 700   | 800   | 900  |
| Dec/15/67 | .760     | .340  | .260  | .116  | .144  | .080  | .048  | .030  | .004 |
| Dec/22/67 | .156     | .217  | .171  | .141  | .095  | .143  | .049  | .074  | .123 |
| Jan/4/68  | .546     | .322  | .258  | .211  | .380  | .119  | .050  | .105  | .298 |
| Jan/11/68 | .222     | .170  | .167  | .154  | .104  | .141  | .154  | .082  | .079 |
| Jan/18/68 | .220     | .205  | .183  | .150  | --*   | .176  | .178  | .051  | .275 |
| Jan/25/68 | .333     | .206  | .123  | .123  | .123  | .112  | .071  | .112  | --   |
| Feb/1/68  | .235     | --    | .150  | --    | --    | .150  | --    | .150  | --   |
| Feb/7/68  | .249     | .215  | .186  | .191  | .130  | .100  | --    | .104  | .182 |
| Feb/15/68 | .528     | .592  | .599  | .603  | .556  | .599  | .233  | .193  | .114 |
| Feb/29/68 | .442     | .521  | .304  | .371  | .446  | .248  | .256  | .205  | .245 |
| Mar/8/68  | .284     | .260  | .192  | .114  | .142  | .168  | .083  | .089  | .109 |
| Mar/14/68 | .360     | .231  | .143  | .105  | .110  | .127  | .079  | .070  | .046 |
| Mar/21/68 | .247     | .256  | .135  | .170  | .242  | .155  | .124  | .087  | .066 |
| Mar/28/68 | .218     | .213  | .156  | .110  | .149  | .088  | .079  | .154  | .061 |
| Apr/11/68 | --       | --    | --    | .235  | .184  | .224  | .106  | .060  | .061 |
| Apr/18/68 | .423     | .371  | .292  | .200  | .146  | .208  | .114  | .142  | .257 |
| Apr/25/68 | .553     | .429  | .466  | .822  | .182  | .423  | .197  | .229  | .414 |
| May/2/68  | 1.267    | .972  | .963  | .889  | .725  | .642  | 1.612 | 1.028 | .449 |
| May/9/68  | 2.853    | 2.853 | 2.723 | 3.224 | 3.076 | 3.372 | 3.020 | 2.872 | --   |
| May/16/68 | 1.684    | 1.480 | 1.095 | 1.041 | 1.008 | 1.149 | 1.331 | .797  | --   |
| May/23/68 | --       | --    | --    | --    | --    | --    | --    | --    | --   |

\*--Indicates that no sample was collected on this date.



TABLE 15  
PROTEIN VALUES CHENA RIVER MG/1

| Date      | STATIONS |       |       |       |       |       |       |       |       |
|-----------|----------|-------|-------|-------|-------|-------|-------|-------|-------|
|           | 100      | 200   | 300   | 400   | 500   | 600   | 700   | 800   | 900   |
| Dec/15/67 | 3.994    | 2.742 | 3.696 | 1.468 | .735  | .871  | .601  | .550  | ---*  |
| Dec/22/67 | .940     | .985  | 1.194 | .664  | .556  | .563  | 1.258 | .301  | .529  |
| Jan/4/68  | 2.450    | 2.998 | 2.064 | 1.193 | 1.292 | 1.231 | 1.171 | 1.374 | 1.304 |
| Jan/11/68 | .372     | .475  | .415  | .242  | .258  | .168  | .213  | .133  | .179  |
| Jan/18/68 | .451     | .413  | .441  | .319  | ---   | .315  | .137  | .217  | .632  |
| Jan/25/68 | .566     | .357  | .168  | .097  | .058  | .049  | .069  | .057  | ---   |
| Feb/1/68  | .375     | ---   | .270  | ---   | ---   | .028  | ---   | .109  | ---   |
| Feb/7/68  | .330     | .364  | .217  | .105  | .138  | .222  | ---   | .101  | .244  |
| Feb/15/68 | .349     | .524  | .050  | .057  | ---   | .048  | ---   | ---   | .035  |
| Feb/29/68 | .448     | 1.314 | .349  | .026  | .258  | .009  | ---   | ---   | .088  |
| Mar/8/68  | .455     | .442  | .614  | .084  | .255  | .092  | .025  | .057  | .057  |
| Mar/14/68 | .284     | .188  | .046  | .025  | .044  | .058  | .044  | .061  | .073  |
| Mar/21/68 | .369     | .420  | .144  | .233  | .482  | .023  | .080  | .020  | .015  |
| Mar/28/63 | .122     | .309  | .134  | .025  | .040  | .035  | .061  | .039  | .005  |
| Apr/11/68 | ---      | ---   | ---   | .105  | .166  | .342  | .071  | .036  | .048  |
| Apr/18/68 | .378     | .374  | .263  | .098  | .147  | .210  | .139  | .137  | .159  |
| Apr/25/68 | .656     | .646  | .360  | .905  | .113  | .460  | .210  | .235  | .335  |
| May/2/68  | .767     | .827  | .806  | .555  | .584  | .331  | 1.089 | .667  | .282  |
| May/9/68  | 2.001    | 1.978 | 2.701 | 2.088 | 2.011 | 1.806 | 2.131 | 1.668 | ---   |
| May/16/68 | 1.067    | .876  | 1.184 | 1.141 | 1.120 | 1.115 | .967  | .985  | ---   |
| May/23/68 | ---      | ---   | ---   | ---   | ---   | ---   | ---   | ---   | ---   |

\*---Indicates that no sample was collected on this date.

TABLE 16  
DISSOLVED OXYGEN

| DATE      | STATION* | DO (ppm) | DATE      | STATION | DO (ppm) |
|-----------|----------|----------|-----------|---------|----------|
| Oct/7/67  | 900      | 13.4     | Nov/4/67  | 900     | 10.7     |
|           | 800      | 13       |           | 800     | 10.8     |
|           | 700      | 5        |           | 700     | 10.5     |
|           | 600      | 12.8     |           | 600     | 10       |
|           | 500      | 12.6     |           | 500     | 9.8      |
|           | 400      | 12.6     |           | 400     | 9        |
|           | 300      | 12.4     |           | 300     | 10       |
|           | 200      | 12.2     |           | 200     | 8.8      |
|           | 100      | 12       |           | 100     | 9.8      |
| Oct/14/67 | 900      | 14.8     | Nov/11/67 | 900     | 11.4     |
|           | 800      | 13.4     |           | 800     | 11.8     |
|           | 700      | 12.8     |           | 700     | 11.8     |
|           | 600      | 12.8     |           | 600     | 9.4      |
|           | 500      | 13       |           | 500     | 9.8      |
|           | 400      | 12.6     |           | 400     | 9        |
|           | 300      | 12.6     |           | 300     | 9        |
|           | 200      | 12.4     |           | 200     | 9.8      |
|           | 100      | 12       |           | 100     | 10       |
| Oct/21/67 | 900      | 13.2     | Nov/17/67 | 900     | 12.4     |
|           | 800      | 12.2     |           | 800     | 11.5     |
|           | 700      | 11.6     |           | 700     | 10.4     |
|           | 600      | 11.4     |           | 600     | 9.3      |
|           | 500      | 11.6     |           | 500     | --       |
|           | 300      | 10.4     |           | 400     | 7.5      |
| Oct/26/67 | 200      | 11.8     |           | 300     | 8.8      |
|           | 100      | 12.2     |           | 200     | 8.8      |
|           |          |          |           | 100     | 9.2      |
| Oct/28/67 | 900      | 11       | Nov/24/67 | 900     | 10.2     |
|           | 800      | 11.2     |           | 800     | 9.4      |
|           | 700      | 11       |           | 700     | 9.4      |
|           | 600      | 11       |           | 600     | 8.8      |
|           | 500      | 10.6     |           | 500     | 8.4      |
|           | 400      | 10.4     |           | 400     | 7.1      |
|           | 300      | 10.6     |           | 300     | 7.4      |
|           | 200      | 10.1     |           | 200     | 8.6      |
|           | 100      | 10.3     |           |         |          |

\*See Figure 2.

TABLE 16 Cont

| DATE         | STATION                                          | DO (ppm) | DATE           | STATION          | DO (ppm)                |
|--------------|--------------------------------------------------|----------|----------------|------------------|-------------------------|
| Dec/8/67     | 900                                              | 9.6      | Jan/11 & 12/68 | 900              | 10.4                    |
|              | 800                                              | 9        |                | 800              | 9.6                     |
|              | 700                                              | 8.5      |                | 700              | 9.5                     |
|              | 600                                              | 7.3      |                | 600              | 8.2                     |
|              | 500                                              | 6.8      |                | 500              | 8.3                     |
|              | 400                                              | 5.3      |                | 400              | 7.1                     |
|              | 300                                              | 6.5      |                | 300              | 6.6                     |
|              | 200                                              | 5        |                | 200              | 7.2                     |
|              | 100                                              | 5.3      |                | 100              | 7.2                     |
| Dec/14/67    | 900                                              | 8.5      | Jan/18 & 19/68 | 900              | 10.2                    |
|              | 800                                              | 7.6      |                | 800              | 8.4                     |
|              | 700                                              | 7.3      |                | 700              | 8.2                     |
|              | 600                                              | 6.4      |                | 600              | 8.8                     |
|              | 500                                              | 5.9      |                | (No date on 500) |                         |
|              | 400                                              | 4.8      |                | 400              | 6.4                     |
|              | 300                                              | 4.6      |                | 300              | 5.4                     |
|              | 200                                              | 4.9      |                | 200              | 5.6                     |
|              | 100                                              | 4.9      |                | 100              | 5.2                     |
| Dec/21/67    | 900                                              | 10.1     | Jan/25/68      | 900              | (roads im-<br>passable) |
|              | 800                                              | 9.7      |                | 800              | 8.3                     |
|              | 700                                              | 9.5      |                | 700              | 8.1                     |
|              | 600                                              | 7.8      |                | 600              | 5.8                     |
|              | 500                                              | 7.3      |                | 500              | 5.3                     |
|              | 400                                              | 6.0      |                | 400              | 3.8                     |
|              | 300                                              | 5.8      |                | 300              | 3.9                     |
|              | 200                                              | 6.3      |                | 200              | 4.6                     |
|              | 100                                              | 6.3      |                | 100              | 4.2                     |
| Dec/28/67    | 900                                              | 11.7     | Feb/1 & 2/68   | 900              | (roads im-<br>passable) |
|              | 800                                              | 9.5      |                | 800              | 8.3                     |
|              | 700                                              | 9.1      |                | 700              | --                      |
|              | (600, 500 & 400 missed due to inclement weather) |          |                | 600              | 6.9                     |
|              | 300                                              | 5.5      |                | 500              | --                      |
|              | 200                                              | 5.7      |                | 400              | --                      |
|              | 100                                              | 6        |                | 300              | 4.7                     |
|              |                                                  |          |                | 200              | --                      |
|              |                                                  |          |                | 100              | 4.7                     |
| Jan/4 & 5/68 | 900                                              | 9.8      | Feb/7/68       | 900              | 8.2                     |
|              | 800                                              | 9.1      |                | 800              | 8.6                     |
|              | 700                                              | 9.2      |                | 700              | --                      |
|              | 600                                              | 9.0      |                | 600              | 6.6                     |
|              | 500                                              | 8.9      |                | 500              | 6.3                     |
|              | 400                                              | 7.8      |                | 400              | 4.9                     |
|              | 300                                              | 7.4      |                | 300              | 3.9                     |
|              | 200                                              | 7.7      |                | 200              | 5.1                     |
|              | 100                                              | 8        |                | 100              | 4.5                     |

TABLE 16 Cont.

| DATE                 | STATION | DO (ppm) | DATE           | STATION | DO (ppm) |
|----------------------|---------|----------|----------------|---------|----------|
| Feb/15/68            | 900     | 7.8      | Mar/28 & 29/68 | 900     | 9.1      |
|                      | 800     | --       |                | 800     | 9.5      |
|                      | 700     | 7.9      |                | 700     | 9.7      |
|                      | 600     | 6.9      |                | 600     | 7        |
|                      | 500     | 7.6      |                | 500     | 6.7      |
|                      | 400     | 5.6      |                | 400     | 5.8      |
|                      | 300     | 5.3      |                | 300     | 5.9      |
|                      | 200     | 5.9      |                | 200     | 6.4      |
|                      | 100     | 5.2      |                | 100     | 6.5      |
| Feb/29 &<br>Mar/1/68 | 900     | 8.8      | Apr/8/68       | 900     | 9.9      |
|                      | 800     | 8.3      |                | 800     | 9.65     |
|                      | 700     | 8.4      |                | 700     | 9.7      |
|                      | 600     | 6.7      |                | 600     | 9.1      |
|                      | 500     | 6.5      |                | 500     | 8.6      |
|                      | 400     | 6.5      |                | 400     | 7.8      |
|                      | 300     | 5.2      |                | 300     | 8.3      |
|                      | 200     | 5.6      |                | 200     | 8.3      |
|                      | 100     | 5.4      |                | 100     | 8.3      |
| Mar/8 & 9/68         | 900     | 10.7     | Apr/11 & 12/68 | 900     | 9.7      |
|                      | 800     | 10.2     |                | 800     | 9.5      |
|                      | 700     | 10.2     |                | 700     | 9.7      |
|                      | 600     | 8.3      |                | 600     | 8.6      |
|                      | 500     | 8        |                | 500     | 8.1      |
|                      | 400     | 6.8      |                | 400     | 7.35     |
|                      | 300     | 6.7      |                | 300     | 7.1      |
|                      | 200     | 7.3      |                | 200     | 7.4      |
|                      | 100     | 7.2      |                | 100     | 7.6      |
| Mar/14 & 15/68       | 900     | 8.1      | Apr/18 & 19/68 | 900     | 9.3      |
|                      | 800     | 9.4      |                | 800     | 9.8      |
|                      | 700     | 9.3      |                | 700     | 9.7      |
|                      | 600     | 7.9      |                | 600     | 8.2      |
|                      | 500     | 7.8      |                | 500     | 8.3      |
|                      | 400     | 6.5      |                | 400     | 7.3      |
|                      | 300     | 7        |                | 300     | 7.4      |
|                      | 200     | 6.7      |                | 200     | 7.8      |
|                      | 100     | 7.2      |                | 100     | 7.6      |
| Mar/21 & 22/68       | 900     | 9.6      | Apr/25 & 26/68 | 900     | 10.9     |
|                      | 800     | 9.3      |                | 800     | 10.1     |
|                      | 700     | 10.2     |                | 700     | 10       |
|                      | 600     | 7.7      |                | 600     | 9.9      |
|                      | 500     | 7.8      |                | 500     | 9.5      |
|                      | 400     | 6.7      |                | 400     | 9.6      |
|                      | 300     | 6.3      |                | 300     | 9.0      |
|                      | 200     | 6.5      |                | 200     | 8.9      |
|                      | 100     | 6.6      |                | 100     | 8.6      |

TABLE 16 Cont.

| DATE           | STATION | DO (ppm)          | DATE      | STATION | DO (ppm) |
|----------------|---------|-------------------|-----------|---------|----------|
| May/2 & 3/68   | 900     | 11.2              | Nov/25/68 | 800     | 9.2      |
|                | 800     | 11.2              |           | 100     | 5.2      |
|                | 700     | 11.4              | Dec/17/68 | 800     | 9.2      |
|                | 600     | 10.5              |           | 100     | 2.8      |
|                | 500     | 10.2              | Jan/7/69  | 800     | 7.2      |
|                | 400     | 10.4              |           | 100     | 1.8      |
|                | 300     | 10.2              | Jan/28/69 | 800     | 9.2      |
|                | 200     | 9.9               |           | 100     | 3.8      |
|                | 100     | 10                | Feb/11/69 | 800     | 8.4      |
| May/9 & 10/68  | 900     | (Road washed out) |           | 100     | 4.1      |
|                | 800     | 12.5              | Mar/3/69  | 800     | 9.0      |
|                | 700     | 13.5              |           | 100     | 5.7      |
|                | 600     | 12.5              | Mar/24/69 | 800     | 9.2      |
|                | 500     | 12                |           | 100     | 5.6      |
|                | 400     | 12                | Apr/14/69 | 800     | 11.0     |
|                | 300     | 10.7              |           | 100     | 6.6      |
|                | 200     | 12.5              | May/5/69  | 800     | 11.9     |
|                | 100     | 12                |           | 100     | 10.9     |
| May/16 & 17/68 | 900     | (Road washed out) |           |         |          |
|                | 800     | 15.0              |           |         |          |
|                | 700     | 11.5              |           |         |          |
|                | 600     | 12.0              |           |         |          |
|                | 500     | 10.6              |           |         |          |
|                | 400     | 12.7              |           |         |          |
|                | 300     | 12.7              |           |         |          |
|                | 200     | 12.6              |           |         |          |
|                | 100     | 12                |           |         |          |
| May/23 & 24/68 | 900     | (Road washed out) |           |         |          |
|                | 800     | 10.5              |           |         |          |
|                | 700     | 10.3              |           |         |          |
|                | 600     | 12.4              |           |         |          |
|                | 500     | 12.3              |           |         |          |
|                | 400     | 11.9              |           |         |          |
|                | 300     | 12                |           |         |          |
|                | 200     | 11.7              |           |         |          |
|                | 100     | 11.6              |           |         |          |
| Oct/21/68      | 800     | 12.0              |           |         |          |
|                | 100     | 10.5              |           |         |          |
| Nov/6/68       | 800     | 11.1              |           |         |          |
|                | 100     | 7.1               |           |         |          |



lower river were recorded. The collection and handling of samples was according to Standard Methods, 12th Edition, 1965, using the "azide iodometric" method of analysis. In the Chena River, dissolved oxygen levels throughout the length of the stream remain very near saturation during the summer. After freezeup (October), the dissolved oxygen declines until late December or early January, when it begins to rise again, reaching saturation at breakup (May). Under ice, the dissolved oxygen decreases progressively downstream until values of less than 2 ppm are reached at station 100. This is lower than the value allowed in the Alaska Water Standards, November 1967. Alaska Department of Fish and Game biologists and others have recorded similar low dissolved oxygen readings from isolated sampling in winter from other streams in the Interior of Alaska. It seems that heavy prolonged snow and ice cover, low light intensity, slow reaeration rate, and low photosynthetic rates account for the decrease in dissolved oxygen.

The conditions presented between stations 400 and 100 on the Chena are modified by the addition of more than 3-million gallons of sewage per day. We should expect that the bacterial action from this load of sewage in a stream the size of the Chena would produce a marked reduction in the dissolved oxygen content of the water. It appears that the low temperature of the water inhibits the expected rate bacterial action. The short distance of flow (15 miles) to the mouth may not allow the adaptation of bacteria found in the sewage to the low temperature. The data in Table 16 is the only information available now and it indicates that there is great need for much further study of the problem to give an answer to the phenomena shown here.

#### Conductivity, pH and Alkalinity

The pH, defined as the negative logarithm of the hydrogen ion activity, is an important constituent when determining the quality of flowing waters. The stability of calcareous exoskeletons, such as those found in the phylum mollusca, is largely determined by the pH of the water in which these organisms live. Waters on the acid side (those below pH of 7) tend to result in the erosion of the shells and, as a result, these organisms are generally not found in waters whose pH's drop significantly below 7 during some part of the year.

It is interesting to note that the pH in the Chena River during the summer was slightly above neutral, ranging from 7.10 to 7.84 (Table 17). These are high enough to sustain the shells of mollusks. In winter, due primarily to the effects of low dissolved oxygen and changes in organism activity, in addition to increased groundwater influences, pH's dipped below 7, ranging as low as 6.22 at one station on January 18, 1968.

The anions that may contribute to the alkalinity are those which form acids that are only weakly dissociated in solution and which can, thus, enter into hydrolysis reactions. In natural water systems, the principal

TABLE 17  
CONDUCTIVITY, pH AND ALKALINITY

| DATE      | STATION | COND. | pH   | ALKALINITY<br>Mg/l | DATE      | STATION            | COND. | pH   | ALKALINITY<br>Mg/l |
|-----------|---------|-------|------|--------------------|-----------|--------------------|-------|------|--------------------|
| Oct/7/67  | 900     | 145.0 | 7.47 | 51.0               | Nov/11/67 | 900                | 158.0 | 7.34 | 58.0               |
|           | 800     | 143.0 | 7.30 | 52.4               |           | 800 <sup>152</sup> | 152.5 | 7.37 | 60.0               |
|           | 700     | 131.0 | 7.32 | 55.8               |           | 700                | 156.0 | 7.35 | 61.0               |
|           | 600     | 132.0 | 7.36 | 58.4               |           | 600                | 151.0 | 7.21 | 62.0               |
|           | 500     | 131.0 | 7.25 | 59.6               |           | 500                | 152.5 | 7.00 | 64.0               |
|           | 400     | 146.6 | 7.21 | 67.8               |           | 400                | 177.5 | 7.32 | 76.0               |
|           | 300     | 168.2 | 7.33 | 71.4               |           | 300                | 185.0 | 7.28 | 80.0               |
|           | 200     | 146.3 | 7.34 | 77.0               |           | 200                | 205.0 | 7.26 | 80.0               |
|           | 100     | 149.9 | 7.41 | 77.0               |           | 100                | 202.5 | 7.32 | 72.0               |
| Oct/14/67 | 900     | 94.0  | 7.32 | 52.6               | Nov/17/67 | 900                | 173.5 | 7.19 | 57.8               |
|           | 800     | 98.0  | 7.29 | 54.0               |           | 800                | 161.0 | 7.02 | 59.6               |
|           | 700     | 106.0 | 7.31 | 48.4               |           | 700                | 167.0 | 7.15 | 59.2               |
|           | 600     | 96.0  | 7.23 | 66.0               |           | 600                | 167.5 | 7.03 | 63.0               |
|           | 500     | 105.0 | 7.17 | 62.0               |           | 400                | 188.0 | 7.05 | 69.6               |
|           | 400     | 112.5 | 7.20 | 64.2               |           | 300                | 186.0 | 7.76 | 68.2               |
|           | 300     | 122.0 | 7.32 | 72.0               |           | 200                | 196.0 | 7.36 | 79.0               |
|           | 200     | 122.5 | 7.33 | 76.2               |           | 100                | 192.5 | 7.18 | 79.2               |
|           | 100     | 119.5 | 7.31 | 74.1               | Nov/24/67 | 900                | 170.7 | 7.27 | 53.0               |
| Oct/21/67 | 900     | 169.0 | 7.48 | 51.6               |           | 800                | 179.4 | 7.32 | 56.0               |
|           | 800     | 169.0 | 7.32 | 59.0               |           | 700                | 173.0 | 7.25 | 60.0               |
|           | 700     | 159.5 | 7.42 | 60.0               |           | 600                | 168.2 | 7.07 | 60.0               |
|           | 600     | 175.0 | 7.48 | 67.0               |           | 500                | 181.9 | 6.94 | 62.0               |
|           | 500     | 150.0 | 7.72 | 61.0               |           | 400                | 185.6 | 7.10 | 72.0               |
|           | 300     | 193.5 | 7.53 | 84.0               |           | 300                | 194.4 | 7.15 | 78.0               |
| Oct/26/67 | 200     | 158.5 | 7.32 | 79.0               |           | 200                | 215.4 | 7.06 | 78.0               |
|           | 100     | 164.5 | 7.35 | 84.0               |           | 100                | 223.4 | 7.13 | 96.0               |
| Oct/28/67 | 900     | 150.0 | 7.45 | 54.0               | Dec/8/67  | 900                | 167.5 | 6.95 | 59.0               |
|           | 800     | 206.0 | 7.30 | 73.0               |           | 800                | 164.5 | 6.96 | 60.0               |
|           | 700     | 145.0 | 7.40 | 55.0               |           | 700                | 159.5 | 6.89 | 61.0               |
|           | 600     | 106.0 | 7.45 | 56.0               |           | 600                | 160.0 | 6.91 | 64.0               |
|           | 500     | 104.5 | 7.00 | 60.0               |           | 500                | 161.0 | 6.92 | 68.0               |
|           | 400     | 171.5 | 7.35 | 69.0               |           | 400                | 176.0 | 6.83 | 75.0               |
|           | 300     | 163.0 | 7.32 | 68.0               |           | 300                | 191.0 | 6.93 | 82.4               |
|           | 200     | 176.0 | 7.78 | 77.0               |           | 200                | 197.5 | 6.91 | 86.0               |
|           | 100     | 186.0 | 7.30 | 80.0               |           | 100                | 210.0 | 6.87 | 90.4               |
| Nov/4/67  | 900     | 149.0 | 7.40 | 56.0               | Dec/14/67 | 900                | 174.0 | 7.4  | 56.0               |
|           | 800     | 145.0 | 7.34 | 59.0               |           | 800                | 167.5 | 7.3  | 56.0               |
|           | 700     | 143.5 | 7.32 | 60.0               |           | 700                | 160.0 | 7.8  | 58.0               |
|           | 600     | 139.0 | 7.53 | 60.0               |           | 600                | 155.0 | 7.1  | 58.0               |
|           | 500     | 145.0 | 7.42 | 64.0               |           | 500                | 165.0 | 7.2  | 63.0               |
|           | 400     | 150.5 | 7.20 | 68.0               |           | 400                | 173.5 | 7.2  | 74.0               |
|           | 300     | 164.5 | 7.16 | 76.0               |           | 300                | 201.0 | 7.7  | 81.0               |
|           | 200     | 167.5 | 7.35 | 78.0               |           | 200                | 210.0 | 7.8  | 87.0               |
|           | 100     | 188.0 | 7.22 | 80.0               |           | 100                | 222.5 | 7.8  | 82.0               |

TABLE 17 Cont.

| DATE              | STATION                                                         | COND  | pH.   | ALKALINITY<br>Mg/l | DATE                 | STATION | COND.              | pH    | ALKALINITY<br>Mg/l |      |
|-------------------|-----------------------------------------------------------------|-------|-------|--------------------|----------------------|---------|--------------------|-------|--------------------|------|
| Dec/21/67         | 900                                                             | 172.5 | 8.4   | 59.0               | Jan/25 &<br>26/68    | 900     | (Roads impassable) |       |                    |      |
|                   | 800                                                             | 170.0 | 8.0   | 60.0               |                      | 800     | 172.0              | 6.65  | 60.0               |      |
|                   | 700                                                             | 171.0 | 7.7   | 62.0               |                      | 700     | 185.0              | 6.61  | 62.0               |      |
|                   | 600                                                             | 167.5 | 7.3   | 60.0               |                      | 600     | 155.0              | 6.84  | 60.0               |      |
|                   | 500                                                             | 168.5 | 7.3   | 64.0               |                      | 500     | 186.0              | 6.66  | 66.0               |      |
|                   | 400                                                             | 189.5 | 7.2   | 76.0               |                      | 400     | 210.0              | 6.72  | 76.0               |      |
|                   | 300                                                             | 169.0 | 7.3   | 80.0               |                      | 300     | 235.0              | 6.84  | 84.0               |      |
|                   | 200                                                             | 210.0 | 7.6   | 86.0               |                      | 200     | 256.0              | 6.58  | 92.0               |      |
|                   | 100                                                             | 207.5 | 7.8   | 82.0               |                      | 100     | 250.0              | 6.57  | 90.0               |      |
| Dec/28/67         | 900                                                             | 145.0 | 6.73  | 52.0               | Feb/1 &<br>2/68      | 800     | 195.0              | 6.90  | 70.0               |      |
|                   | 800                                                             | 140.0 | 6.74  | 54.0               |                      | 600     | 175.0              | 6.95  | 60.0               |      |
|                   | 700                                                             | 136.0 | 6.65  | 54.0               |                      | 300     | 235.0              | 7.14  | 90.0               |      |
|                   | (Stations 600, 500 & 400<br>missed due to inclement<br>weather) |       |       |                    |                      | 100     | 254.0              | 7.01  | 86.0               |      |
|                   | 300                                                             | 225.0 | 7.02  | 78.0               | Feb/7/68             | 900     | 190.0              | 6.74  | 54.0               |      |
|                   | 200                                                             | 195.0 | 7.14  | 86.0               |                      | 800     | 185.0              | 6.83  | 58.0               |      |
|                   | 100                                                             | 170.0 | 7.06  | 84.0               |                      | 600     | 165.0              | 6.87  | 60.0               |      |
|                   | Jan/4 &<br>5/68                                                 | 900   | 150.0 | 6.77               |                      | 51.8    | 500                | 160.0 | 6.92               | 63.0 |
|                   |                                                                 | 800   | 150.0 | 6.65               |                      | 56.0    | 400                | 190.0 | 6.83               | 78.0 |
| 700               |                                                                 | 150.0 | 6.77  | 52.6               |                      | 300     | 210.0              | 6.75  | 80.0               |      |
| 600               |                                                                 | 173.0 | 7.2   | 60.0               |                      | 200     | 235.0              | 6.72  | 92.0               |      |
| 500               |                                                                 | 176.0 | 6.97  | 62.0               |                      | 100     | 225.0              | 6.89  | 86.0               |      |
| 400               |                                                                 | 195.0 | 7.0   | 72.0               | Feb/15/68            | 900     | 149.0              | 6.73  | 62.0               |      |
| 300               |                                                                 | 174.0 | 7.07  | 78.0               |                      | 800     | 140.0              | 6.82  | 64.0               |      |
| 200               |                                                                 | 221.0 | 7.12  | 80.0               |                      | 700     | 142.0              | 6.84  | 60.0               |      |
| 100               |                                                                 | 230.0 | 7.08  | 84.0               |                      | 600     | 151.0              | 6.65  | 60.0               |      |
| Jan/11 &<br>12/68 | 900                                                             | 164.0 | 6.91  | 52.0               |                      | 500     | 165.0              | 6.76  | 68.0               |      |
|                   | 800                                                             | 147.0 | 6.80  | 60.0               |                      | 400     | 182.0              | 6.86  | 76.0               |      |
|                   | 700                                                             | 169.0 | 6.55  | 58.0               |                      | 300     | 193.0              | 6.86  | 80.0               |      |
|                   | 600                                                             | 172.0 | 6.50  | 60.0               |                      | 200     | 215.0              | 6.85  | 88.0               |      |
|                   | 500                                                             | 173.0 | 6.39  | 60.0               |                      | 100     | 200.0              | 7.13  | 80.0               |      |
|                   | 400                                                             | 195.0 | 6.42  | 70.0               | Feb/29 &<br>Mar/1/68 | 900     | 170.0              | 7.12  | 64.0               |      |
|                   | 300                                                             | 198.0 | 6.59  | 78.0               |                      | 800     | 155.0              | 7.16  | 60.0               |      |
|                   | 200                                                             | 212.0 | 6.45  | 78.0               |                      | 700     | 168.0              | 7.23  | 68.0               |      |
|                   | 100                                                             | 219.0 | 6.51  | 78.0               |                      | 600     | 151.0              | 7.19  | 66.0               |      |
| Jan/18 &<br>19/68 | 900                                                             | 158.0 | 6.91  | -                  |                      | 500     | 170.0              | 7.21  | 70.0               |      |
|                   | 800                                                             | 152.0 | 6.72  | -                  |                      | 400     | 177.0              | 7.27  | 78.0               |      |
|                   | 700                                                             | 147.0 | 6.95  | -                  |                      | 300     | 205.0              | 7.35  | 86.0               |      |
|                   | 600                                                             | 142.0 | 6.52  | 65.0               |                      | 200     | 195.0              | 7.32  | 90.0               |      |
|                   | 400                                                             | 162.0 | 6.15  | 70.0               |                      | 100     | 225.0              | 7.41  | 96.0               |      |
|                   | 300                                                             | 172.0 | 6.22  | 80.0               |                      |         |                    |       |                    |      |
|                   | 200                                                             | 178.0 | 6.35  | 76.0               |                      |         |                    |       |                    |      |
|                   | 100                                                             | 189.0 | 6.62  | 84.0               |                      |         |                    |       |                    |      |

TABLE 17 Cont.

| DATE              | STATION | COND. | ALKALINITY |      | DATE              | STATION | COND.             | ALKALINITY |      |
|-------------------|---------|-------|------------|------|-------------------|---------|-------------------|------------|------|
|                   |         |       | pH         | Mg/l |                   |         |                   | pH         | Mg/l |
| Mar/8 &<br>9/68   | 900     | 175   | 7.13       | 60   | Apr/18 &<br>19/68 | 900     | 162               | 7.125      | 64   |
|                   | 800     | 180   | 7.10       | 52   |                   | 800     | 148               | 7.179      | 68   |
|                   | 700     | 165   | 7.14       | 54   |                   | 700     | 134               | 7.249      | 66   |
|                   | 600     | 165   | 7.12       | 62   |                   | 600     | 134               | 7.158      | 64   |
|                   | 500     | 163   | 7.12       | 70   |                   | 500     | 132               | 7.057      | 64   |
|                   | 400     | 180   | 7.08       | 76   |                   | 400     | 174               | 6.941      | 36   |
|                   | 300     | 157   | 7.17       | 84   |                   | 300     | 169               | 6.245      | 94   |
|                   | 200     | 215   | 7.22       | 90   |                   | 200     | 203               | 7.163      | 96   |
|                   | 100     | 212   | 7.21       | 92   |                   | 100     | 203               | 7.151      | 98   |
| Mar/13 &<br>14/68 | 900     | 150   | 6.825      | 64   | Apr/25 &<br>26/68 | 900     | 170               | 7.195      | 60   |
|                   | 800     | 175   | 6.862      | 66   |                   | 800     | 153               | 7.393      | 68   |
|                   | 700     | 162   | 6.915      | 58   |                   | 700     | 165               | 7.129      | 66   |
|                   | 600     | 161   | 6.937      | 61   |                   | 600     | 175               | 7.325      | 64   |
|                   | 500     | 162   | 6.832      | 66   |                   | 500     | 180               | 6.975      | 72   |
|                   | 400     | 160   | 6.905      | 74   |                   | 400     | 210               | 7.055      | 84   |
|                   | 300     | 202   | 6.030      | 86   |                   | 300     | 230               | 7.169      | 92   |
|                   | 200     | 207   | 7.013      | 86   |                   | 200     | 205               | 7.275      | 96   |
|                   | 100     | 208   | 7.035      | 86   |                   | 100     | 236               | 7.276      | 82   |
| Feb/21 &<br>22/68 | 900     | 182   | 6.945      | 60   | May/2 &<br>3/68   | 900     | 158               | 7.041      | 59   |
|                   | 800     | 190   | 6.865      | 62   |                   | 800     | 124               | 7.181      | 51   |
|                   | 700     | 161   | 6.917      | 62   |                   | 700     | 100               | 6.940      | 41   |
|                   | 600     | 159   | 6.873      | 62   |                   | 600     | 134               | 7.215      | 60   |
|                   | 500     | 175   | 6.805      | 64   |                   | 500     | 135               | 6.949      | 62   |
|                   | 400     | 195   | 6.875      | 80   |                   | 400     | 138               | 7.212      | 62   |
|                   | 300     | 216   | 6.940      | 86   |                   | 300     | 136               | 7.039      | 68   |
|                   | 200     | 198   | 7.049      | 94   |                   | 200     | 136               | 7.098      | 70   |
|                   | 100     | 213   | 6.965      | 72   |                   | 100     | 144               | 7.040      | 66   |
| Mar/28 &<br>29/68 | 900     | 190   | 6.890      | 60   | May/9 &<br>10/68  | 900     | (Road washed out) |            |      |
|                   | 800     | 188   | 6.832      | 62   |                   | 800     | 72                | 6.925      | 28   |
|                   | 700     | 153   | 6.850      | 60   |                   | 700     | 67.5              | 7.115      | 26   |
|                   | 600     | 164   | 6.962      | 54   |                   | 600     | 76                | 7.035      | 34   |
|                   | 500     | 155   | 5.825      | 64   |                   | 500     | 75                | 6.995      | 28   |
|                   | 400     | 193   | 6.893      | 84   |                   | 400     | 78                | 7.105      | 30   |
|                   | 300     | 220   | 7.045      | 90   |                   | 300     | 77                | 6.940      | 31   |
|                   | 200     | 230   | 7.072      | 94   |                   | 200     | 75                | 6.935      | 32   |
|                   | 100     | 225   | 7.102      | 96   |                   | 100     | 75                | 7.085      | 15   |
| Apr/11 &<br>12/68 | 900     | 163   | 7.04       | 64   | May/16 &<br>17/68 | 900     | 92                | 7.01       | 38   |
|                   | 800     | 160   | 7.02       | 64   |                   | 700     | 94                | 7.04       | 34   |
|                   | 700     | 165   | 7.10       | 68   |                   | 600     | 88                | 7.235      | 42   |
|                   | 600     | 184   | 7.05       | 72   |                   | 500     | 96                | 7.175      | 42   |
|                   | 500     | 173   | 6.98       | 68   |                   | 400     | 96                | 7.07       | 60   |
|                   | 400     | 215   | 7.08       | 90   |                   | 300     | 85                | 6.95       | 100  |
|                   | 300     | -     | -          | -    |                   | 200     | 82                | 6.96       | 42   |
|                   | 200     | 220   | 7.17       | 96   |                   | 100     | 60                | 7.06       | 18   |

TABLE 17 Cont.

| DATE              | STATION | COND. | pH   | ALKALINITY |
|-------------------|---------|-------|------|------------|
|                   |         |       |      | Mg/l       |
| May/23 &<br>24/68 | 800     | 109   | 7.01 | 48         |
|                   | 700     | 100   | 7.81 | 40         |
|                   | 600     | 86    | 6.99 | 40         |
|                   | 500     | 88    | 7.02 | 44         |
|                   | 400     | 84    | 7.03 | 40         |
|                   | 300     | 82    | 7.09 | 36         |
|                   | 200     | 82    | 6.97 | 40         |
|                   | 100     | 80    | 7.09 | 38         |



anions contributing to the alkalinity are bicarbonate, carbonate, silicate, and hydroxide. Organic anions, phosphate, borate, and fluoride can also contribute to alkalinity, if present in high enough concentrations. In the Chena River, the principal constituent of alkalinity is the carbon dioxide-carbonate-bicarbonate equilibrium.

Carbon dioxide is necessary for the photosynthetic process and high carbon dioxide may lead to rapid phytoplankton production. It has been found that most waters contain more than sufficient carbon dioxide and that mineral nutrients are the limiting factors with respect to the photosynthetic process and the growth of phytoplankton.

It is interesting to observe that the total alkalinities of May 9, 1967, were significantly lower than those taken during the other sampling periods (Table 17). This is the result of high runoff which introduced large amounts of surface water. On July 5, 1967, alkalinity again increased to 40-75 mg/l throughout the summer months. Once the river had frozen over, alkalinity appeared to climb. This may be caused by either of two factors. One is the change resulting from the introduction of groundwater (during the winter months, the water in the Chena River is principally from groundwater sources) or underwater flow in bed gravels. This obviates any surface water influences. In addition, removal of carbon dioxide by phytoplankton is expected to be lowest during the winter, which could be a cause of the higher alkalinities found on December 30, 1968.

Additional information to substantiate conclusions concerning the samples taken on May 9, 1967, is gained from the conductivity data (Table 17). A determination such as conductivity is a measure of the gross ion concentration in the water. Conductivities taken at these times were significantly lower than those taken at any other time.

#### Other Determinations

In addition to the parameters mentioned above, a small number of additional, less important determinations were made. Hardness is a reduction of calcium and magnesium concentrations to their equivalents in calcium carbonate. Other determinations made included chloride, sulfate, turbidity, and on occasion, color (Table 18). Color appeared to be significant only in the sense that the color of the water during the spring runoff period was high; during the summer it lowered to a level of from 10-45 color units. Turbidity did not seem to be highly variable or important as a pollution indicator. Sulfate, in general, seemed to be much higher in the upper river than in the lower river. Calcium sulfate, for example, may precipitate out in the course of the river's activities, or the sulfate concentration may be diluted by introduction of water from tributaries containing low sulfate.

TABLE 18  
OTHER DETERMINATIONS

| DATE                                              | STATIONS |      |     |     |     |     |     |     |     |
|---------------------------------------------------|----------|------|-----|-----|-----|-----|-----|-----|-----|
|                                                   | 100      | 200  | 300 | 400 | 500 | 600 | 700 | 800 | 900 |
| <u>SULFATE MG/1</u>                               |          |      |     |     |     |     |     |     |     |
| May/9/67                                          | 11       | 11   | 11  | --  | 11  | 12  | 12  | 11  | 12  |
| Jul/5/67                                          | 10       | 10   | 11  | 10  | 10  | 10  | 10  | 10  | 12  |
| Sep/26/67                                         | 15       | 15   | 15  | 15  | 15  | 15  | 16  | 17  | 18  |
| Apr/8/68                                          | 17       | 17   | 16  | 16  | 17  | 18  | 22  | 25  | 28  |
| Sep/4/68                                          | --       | --   | --  | --  | --  | --  | --  | --  | --  |
| Dec/30/68                                         | 17       | 6    | 16  | 13  | 12  | 14  | 19  | 23  | 22  |
| <u>CHLORIDE MG/1</u>                              |          |      |     |     |     |     |     |     |     |
| May/9/67                                          | 1.1      | 1.1  | 0.9 | 0.9 | 0.8 | 0.9 | 0.8 | 0.9 | 0.8 |
| Jul/5/67                                          | 0.8      | 0.7  | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Sep/26/67                                         | 1.3      | 1.3  | 0.9 | 0.8 | 0.8 | 0.9 | 0.8 | 0.7 | 0.9 |
| Apr/8/68                                          | 2.4      | 2.1  | 1.5 | 0.6 | 0.6 | 0.8 | 0.6 | 0.8 | 0.9 |
| Sep/4/68                                          | 1.4      | 1.4  | 1.1 | 0.6 | 1.4 | 0.9 | 1.2 | 0.9 | 1.0 |
| Dec/30/68                                         | 2.1      | 10.1 | 1.9 | 9.8 | 0.7 | 0.3 | 0.3 | 0.5 | 0.5 |
| <u>TURBIDITY, HELLINGE, SiO<sub>2</sub>, MG/1</u> |          |      |     |     |     |     |     |     |     |
| May/9/67                                          | 5.7      | 7.0  | 5.9 | 5.3 | 5.3 | 4.0 | 5.9 | 4.4 | 2.3 |
| Jul/5/67                                          | 2.9      | 2.3  | 2.9 | 3.2 | 2.3 | 1.0 | 0.7 | 0.8 | 0.6 |
| Sep/26/67                                         | 6.0      | 5.4  | 3.7 | 2.0 | 3.7 | 1.0 | 2.6 | 2.6 | 1.5 |
| Sep/4/68                                          | 8.0      | 10.0 | 6.0 | 8.0 | 6.0 | 6.0 | 2.5 | 0.5 | 0.5 |
| <u>COLOR, PT. UNITS</u>                           |          |      |     |     |     |     |     |     |     |
| May/9/67                                          | 180      | 120  | 180 | 180 | 180 | 180 | 120 | 120 | 100 |
| Jul/5/67                                          | 45       | 45   | 45  | 45  | 45  | 30  | 25  | 25  | 25  |
| Sep/4/68                                          | 40       | 45   | 40  | 45  | 45  | 40  | 5   | 10  | 10  |

Chloride was determined principally to correct for the chloride oxidation problem in chemical oxygen demand. It doesn't appear to be significant, except that it is generally higher in the lower river, which is probably because most of the sewage effluent from municipal waste treatment plants is chlorinated in addition to containing high sodium chloride. This would tend to increase the chloride below sewage outfalls in the lower river.

## SECTION VI

### BIOLOGY OF THE CHENA RIVER

The aquatic flora and fauna of a river are the end product of environmental conditions in a body of water. Chemical and physical properties of the water, the stream bed and the entire watershed are reflected in the aquatic community. This community is intimately associated with land use, which ultimately is the river use. Alterations in the chemical and physical properties of the stream result in significant changes in the biological populations. If the primary productivity of the stream is changed, the aquatic population will be further altered, which in turn, will produce further change in the chemical makeup of the stream. All are so intimately related that, were the tool for measurement sensitive enough, changes could be found from the slightest perturbation of the natural environment.

The triangular dip net is used to collect a qualitative sample of the aquatic life from any position in the water column that can be reached. The Wisconsin plankton Net is used to capture the smaller organisms free-floating and swimming in the water column. (Standard Methods - Water and Wastewater, 12th Edition, 1965)

The Surber and triangular net collections often contain considerable quantities of debris. The flotation technique of Anderson (1959) can be used to separate the organisms from the trash and facilitate sorting. The sorted samples are usually preserved in a 10 percent solution of formalin and stored in labeled vials for identification and tabulation. The most important factor in the evaluation of the ecological condition of a stream is the skill and good judgement of the aquatic biologist in the selection of sampling sites and the manipulation of equipment.

#### Plankton

The free-floating microscopic plants and animals found in the water are designated as plankton. These organisms constitute the lower links in the food chain, the minute one-celled algae, diatoms, and animal forms. By some definitions, they are referred to as non-motile, but this is not always true for many of the algae possess flagella and the protozoans cilia. Phytoplankton blooms are much less pronounced in rivers than in lakes by reason of their being moved constantly downstream away from the initial biotope. There are definite blooms at all seasons of the year in streams. The slower the stream flow, the more pronounced the bloom of plankton. The plant forms are generally more numerous in the upper layers of the water, they are dependent upon sunlight for the photosynthetic process. The collection of the floating organisms was with the use of the Wisconsin plankton net for quantitative data and fine mesh dip nets for the qualitative presence of the plankton in the water column. The plankton (Table 19) consist mostly of diatoms, which have

TABLE 19

FIVE-MINUTE PLANKTON SAMPLES FROM STATIONS  
ON THE CHENA RIVER AND ITS MAJOR TRIBUTARIES

|                           | CHENA RIVER |       |       |       |       | CHENA RIVER TRIBUTARIES |       |        |        |        |
|---------------------------|-------------|-------|-------|-------|-------|-------------------------|-------|--------|--------|--------|
|                           | C-100       | C-500 | C-600 | C-800 | C-900 | LM-100                  | M-100 | NF-100 | FF-100 | LC-100 |
| <u>Phytoplankton</u>      |             |       |       |       |       |                         |       |        |        |        |
| <u>Bacillariophyceae</u>  |             |       |       |       |       |                         |       |        |        |        |
| <u>Fragilariaceae</u>     |             |       |       |       |       |                         |       |        |        |        |
| <u>Ceratoneis arcus</u>   |             | X     |       | X     | X     | X                       | X     | X      | X      |        |
| <u>Fragilaria sp.</u>     |             | X     | X     | X     | X     |                         | X     |        | X      |        |
| <u>Diatoma sp.</u>        |             |       |       | X     | X     |                         | X     |        | X      |        |
| <u>Meridion circulare</u> |             |       |       |       | X     | X                       |       |        |        |        |
| <u>Tabellaria sp.</u>     |             |       | X     | X     |       |                         |       | X      |        |        |
| <u>Synedra ulna</u>       | X           | X     | X     | X     | X     | X                       | X     | X      | X      | X      |
| <u>Synedra sp.</u>        | X           |       |       |       |       |                         |       |        |        |        |
| <u>Naviculaceae</u>       |             |       |       |       |       |                         |       |        |        |        |
| <u>Diploneis sp.</u>      |             |       |       |       | X     |                         |       |        |        |        |
| <u>Navicula sp.</u>       |             |       |       |       | X     |                         |       |        |        |        |
| <u>Pinnularia sp.</u>     |             |       |       |       |       |                         | X     |        |        |        |
| <u>Stauroneis sp.</u>     |             |       | X     |       |       |                         | X     |        |        |        |
| <u>Gomphonemaceae</u>     |             |       |       |       |       |                         |       |        |        |        |
| <u>Gomphonema sp.</u>     |             | X     |       |       | X     | X                       |       |        |        |        |
| <u>Achnanthaceae</u>      |             |       |       |       |       |                         |       |        |        |        |
| <u>Achnanthes sp.</u>     |             |       |       | X     | X     |                         |       | X      |        |        |
| <u>Eunotiaceae</u>        |             |       |       |       |       |                         |       |        |        |        |
| <u>Eunotia sp.</u>        |             |       |       |       |       |                         |       | X      |        |        |
| <u>Chlorophyta</u>        |             |       |       |       |       |                         |       |        |        |        |
| <u>Chlorophyceae</u>      |             |       |       |       |       |                         |       |        |        |        |
| <u>Chaetophoraceae</u>    |             |       |       |       |       |                         |       |        |        |        |
| <u>Draparnaldia sp.</u>   |             |       |       |       |       |                         | X     |        |        |        |
| <u>Stigeolonium sp.</u>   |             | X     |       |       |       | X                       |       | X      |        |        |
| <u>Zygnemataceae</u>      |             |       |       |       |       |                         |       |        |        |        |
| <u>Spirogyra sp.</u>      |             |       |       |       |       |                         | X     |        |        |        |
| <u>Desmidiaceae</u>       |             |       |       |       |       |                         |       |        |        |        |
| <u>Closterium sp.</u>     |             | X     | X     |       |       |                         |       |        |        |        |
| <u>Ochromonadaceae</u>    |             |       |       |       |       |                         |       |        |        |        |
| <u>Dinobryon sp.</u>      |             | X     |       |       |       |                         |       |        |        |        |
| <u>Oocystaceae</u>        |             |       |       |       |       |                         |       |        |        |        |
| <u>Chlorella sp.</u>      |             | X     | X     |       |       |                         |       |        |        |        |
| <u>Myxophyceae</u>        |             |       |       |       |       |                         |       |        |        |        |
| <u>Oscillatoriaceae</u>   |             |       |       |       |       |                         |       |        |        |        |
| <u>Oscillatoria sp.</u>   | X           | X     |       |       |       |                         |       | X      |        |        |
| <u>Spirulina sp.</u>      |             |       |       | X     |       |                         |       |        |        |        |
| <u>Rhodophyta</u>         |             |       |       |       |       |                         |       |        |        |        |
| <u>Rhodophyceae</u>       |             |       |       |       |       |                         |       |        |        |        |
| <u>Batrachospermaceae</u> |             |       |       |       |       |                         |       |        |        |        |
| <u>Batrachosperma sp.</u> |             |       |       |       |       | X                       |       |        |        |        |
| <u>Zooplankton</u>        |             |       |       |       |       |                         |       |        |        |        |
| <u>Cladocera</u>          | X           |       |       | X     |       |                         |       |        |        |        |
| <u>Ostracoda</u>          |             | X     |       |       |       |                         |       |        |        |        |



probably broken free from the carpet of growth on the river bottom. Zooplankton is represented by two groups, cladocera and ostrocodea. It is interesting to note that the generic variation increases toward the headwaters.

Populations from the tributaries are very similar except for the Little Chena (Station L. C. 100) in which only one species of phytoplankton is represented. At the time of sampling, there was considerable mining activity on the upper reaches of the stream and, as a result, the stream was carrying a heavy silt load. This could explain the lack of a more diverse population

### Periphyton

The bottom surface of a river system is covered with a layer of microorganisms. The water flows through and over this layer, carrying nutrients to these organisms and removing waste products. This film consists of bacteria, fungi, protozoans, and algae. In many habitats, diatoms are the most abundant organisms. Because of this, many researchers feel that they are excellent indicators of environmental conditions in the aquatic habitat. Although considerable work has been done on periphyton, most of it is of a qualitative nature. Samplers, such as glass slides or masonite slabs, have been utilized to sample the population quantitatively. However, none has proven entirely satisfactory. The periphyton data in this paper are qualitative and were collected from rocks and debris on the banks and bottom of the stream. The diatoms are most abundant (Table 20).

The data from the upper river stations and the stations of the tributaries show that, at times, extremely large numbers of periphyton were present. Late in the fall there is a bloom of organisms which casts a brown appearance over the entire river. This activity is not restricted to the warm weather since the fast, open riffles will sometimes develop similar blooms during the winter when the air temperature is hovering at -40 to -50°C. Examination of the material presented in Table 20 shows a definite absence of many of the periphyton genera from the 100 and 200 sampling sites. Figure 2 presents these sites as within the section of the river most subject to domestic sewage pollution.

### Bottom Fauna

The bottom fauna of the Chena River consists primarily of insects. Many of these are immature forms and after several instar stages, will metamorphose into free-flying adults. These members of the benthic community are basic food items of most small fish and many large ones. They transform a large portion of plant and animal debris into animal tissue and, therefore, are an important link in the food chain between the nonliving

TABLE 20

QUALITATIVE PERIPHYTON DATA FROM FIVE STATIONS ON THE CHENA RIVER AND ITS MAJOR TRIBUTARIES-1966

| ORGANISMS                     | CHENA RIVER |     |     |     |     |        |       |        |        |        | CHENA RIVER TRIBUTARIES |  |   |  |   |
|-------------------------------|-------------|-----|-----|-----|-----|--------|-------|--------|--------|--------|-------------------------|--|---|--|---|
|                               | 100         | 300 | 600 | 800 | 900 | LM-100 | M-100 | NF-100 | SF-100 | LC-100 |                         |  |   |  |   |
| <i>Synedra</i> sp.            | X           |     | X   | X   | X   | X      | X     |        | X      | X      |                         |  |   |  |   |
| <i>Navicula</i> sp.           | X           |     | X   | X   | X   | X      | X     |        | X      | X      |                         |  |   |  |   |
| <i>Melosira</i> sp.           | X           | X   | X   |     |     | X      |       |        |        |        |                         |  |   |  |   |
| <i>Gomphonema</i> sp.         | X           |     | X   | X   | X   |        |       |        |        |        |                         |  |   |  |   |
| <i>Diatoma</i> sp.            | X           |     | X   | X   | X   |        |       |        |        |        |                         |  |   |  |   |
| <i>Cymbella</i> sp.           |             |     | X   | X   | X   | X      | X     |        | X      |        |                         |  |   |  |   |
| <i>Fragilaria</i>             |             | X   | X   | X   | X   | X      | X     |        | X      |        |                         |  |   |  |   |
| <i>Achnanthes</i> sp.         |             |     | X   | X   | X   | X      | X     |        | X      |        |                         |  |   |  | X |
| <i>Geratoneis arcus</i>       |             |     | X   | X   | X   | X      | X     |        | X      |        |                         |  |   |  | X |
| <i>Didymosphenia geminata</i> |             |     | X   | X   | X   | X      | X     |        | X      |        |                         |  |   |  | X |
| <i>Stauroneis</i> sp.         |             |     | X   | X   | X   | X      | X     |        | X      |        |                         |  |   |  |   |
| <i>Tabellaria</i> sp.         |             |     | X   |     | X   |        | X     |        |        |        |                         |  |   |  |   |
| <i>Eunotia</i> sp.            |             |     |     | X   | X   |        |       |        |        |        |                         |  |   |  |   |
| <i>Tetrocyclus</i> sp.        |             |     |     | X   | X   |        |       |        |        |        |                         |  |   |  |   |
| <i>Meridium circulare</i>     |             |     |     | X   |     |        |       |        |        |        |                         |  |   |  |   |
| <i>Diploneis</i> sp.          |             |     |     |     | X   | X      |       |        | X      |        |                         |  |   |  |   |
| <i>Cocconeis</i> sp.          |             |     |     |     |     | X      | X     |        |        |        |                         |  |   |  | X |
| <i>Cocconeis</i> sp.          |             |     |     |     |     | X      | X     |        |        |        |                         |  |   |  |   |
| <i>Nitzschia</i> sp.          |             |     |     |     |     | X      | X     |        |        |        |                         |  |   |  |   |
| <i>Closterium</i> sp.         |             |     |     |     |     |        |       |        |        |        |                         |  | X |  |   |
| <i>Cladophora</i> sp.         |             | X   |     |     |     |        | X     |        |        |        |                         |  |   |  |   |
| <i>Spirulina</i> sp.          |             | X   |     |     |     |        |       |        |        |        |                         |  |   |  |   |
| <i>Oscillatoria</i> sp.       |             |     | X   |     |     |        |       |        |        |        |                         |  |   |  |   |
| <i>Mougeotia</i> sp.          |             |     | X   |     | X   |        |       |        |        |        |                         |  |   |  | X |
| <i>Ulothrix</i> sp.           |             |     | X   |     | X   |        |       |        |        |        |                         |  | X |  |   |
| <i>Crucigenia</i> sp.         |             |     |     |     |     |        | X     |        |        |        |                         |  | X |  |   |
| <i>Spirogyra</i> sp.          |             |     |     |     | X   |        |       |        |        |        |                         |  | X |  |   |
| <i>Batrachospermum</i> sp.    | X           |     |     |     |     |        |       |        |        |        |                         |  |   |  |   |
| <i>Draparnaldia</i> sp.       |             |     |     |     |     |        | X     |        |        |        |                         |  | X |  |   |
|                               |             |     |     |     |     |        |       | X      |        |        |                         |  |   |  |   |
| GROUP FREQUENCY               | 6           | 5   | 15  | 12  | 13  | 9      | 15    | 14     | 11     | 8      |                         |  |   |  |   |

organic matter and fish. As a result, they are important indicators of the general productivity of a body of water.

Qualitative samples were collected in August of 1966 (Table 21), July and September 1967 (Table 22), and April and September 1968 (Table 23), from the Chena and its four main tributaries. These collections extend over a considerable time period, and bracket the major flood which occurred in August 1967.

In August 1966, five river stations and four tributaries were sampled. Table 21 gives the data from these stations and Figure 2 shows their locations. This series was designated to produce data which would describe the diversity of the aquatic fauna of the Chena River and its major tributaries. Although it would have been desirable to have data extending over the entire year, the August sampling gives a fairly detailed picture of the diversity of the bottom organisms present in these streams. The knowledge developed from later sampling on the Chena and other streams of Alaska indicates that there is a greater diversity of organisms in samples collected in the fall than at any other time of the year.

In the August 1966 series of samples, there are representatives of each of the following groups: aquatic earthworms, water mites, stoneflies (eight species), mayflies (ten species), caddisflies (six species), crane flies (two species), midges (thirteen+ species), snipeflies, houseflies, mothflies (two species) and back swimmers.

Table 22 presents the data collected in July and September of 1967. . Rainfall was abnormally high which might account for the reduction in diversity of organisms in July in comparison with the previous August (Table 21). Spring and summer genera seem to be less variable. This reduction in diversity is probably caused by emergence, unhatched organisms or very small imagoes.

There were thirteen species represented at station 200, five at 300, five at 600, eight at 700, nine at 800, and eleven at 900 (Table 22). This series produced representatives from the aquatic earthworms, water mites, stoneflies (four species), mayflies (five species), caddisflies (six species), crane flies, backflies (two species), midges (seven species), and snipeflies. Very soon after this sampling period, the area was subjected to the flood of August 1967, which altered much of the river channel. Old, well-established riffles were gone and new ones took their place. As a result of these changes, it was necessary to collect another series of samples after the water returned to normal. This series was collected in September 1967 and, although in some cases, it was necessary to find new sampling areas, all stations were still within a few hundred yards of the originally established points.

Past experience indicated that the genera should have been at their greatest variation during September; however, the data presented in

TABLE 21

QUALITATIVE DATA, AQUATIC INVERTEBRATES-CHENA RIVER AND MAJOR TRIBUTARIES-1966

| ORGANISMS              | S T A T I O N S |     |     |     |     |                         |        |        |       |  |
|------------------------|-----------------|-----|-----|-----|-----|-------------------------|--------|--------|-------|--|
|                        | CHENA RIVER     |     |     |     |     | CHENA RIVER TRIBUTARIES |        |        |       |  |
|                        | 200             | 500 | 600 | 800 | 900 | LC-100                  | NF-100 | SF-100 | M-100 |  |
| Oligochaetes           |                 |     |     |     |     |                         |        |        |       |  |
| Naididae               | X               |     |     |     |     |                         |        |        |       |  |
| Hydracarina            |                 |     |     |     |     |                         |        |        |       |  |
| Lebertiidae            |                 |     |     |     |     |                         |        |        |       |  |
| Libertia sp.           |                 | X   |     |     |     |                         |        |        |       |  |
| Plecoptera             |                 |     |     |     |     |                         |        |        |       |  |
| Brachyptera sp.        | X               |     |     |     |     |                         |        |        |       |  |
| Isoperla signata       | X               |     |     |     |     |                         |        |        |       |  |
| Isoperla marilyni      | X               |     |     |     |     |                         |        |        |       |  |
| Isoperla transmarina   | X               |     |     |     |     |                         |        |        |       |  |
| Alloperla sp. A.       |                 | X   |     |     |     |                         |        |        |       |  |
| Alloperla sp. B.       |                 |     | X   |     |     |                         |        |        |       |  |
| Isogenus sp.           |                 |     | X   |     |     |                         |        |        |       |  |
| Paraperla sp.          |                 |     |     |     |     |                         |        |        |       |  |
| Ephemeroptera          |                 |     |     |     |     |                         |        |        |       |  |
| Ephemerella infrequens | X               |     | X   |     |     |                         |        |        |       |  |
| Ephemerella sp.        | X               |     |     |     |     |                         |        |        |       |  |
| Heptagenia elegantola  | X               |     | X   |     |     |                         |        |        |       |  |
| Pseudocloeon sp.       | X               |     | X   |     |     |                         |        |        |       |  |
| Paracloeon sp.         |                 | X   | X   |     |     |                         |        |        |       |  |
| Metatropus sp.         |                 |     | X   |     |     |                         |        |        |       |  |
| Iron santa-gabriel     |                 |     | X   |     |     |                         |        |        |       |  |
| Cinygmula sp.          |                 |     | X   |     |     |                         |        |        |       |  |
| Edmundsius sp.         |                 |     |     |     |     |                         |        |        |       |  |
| Ephemerella doddsi     |                 |     |     |     |     |                         |        |        |       |  |
| Trichoptera            |                 |     |     |     |     |                         |        |        |       |  |
| Limnephilus sp.        |                 |     |     |     |     |                         |        |        |       |  |
| Pycnopsycha sp. A.     |                 |     |     |     |     |                         |        |        |       |  |
| Pycnopsycha sp. B.     | X               |     | X   |     |     |                         |        |        |       |  |
| Pycnopsycha sp. C.     |                 |     | X   |     |     |                         |        |        |       |  |
| Lepidostoma sp.        |                 |     | X   |     |     |                         |        |        |       |  |
| Neuroclipsis sp.       |                 |     |     |     |     |                         |        |        |       |  |

TABLE 21 Continued

| ORGANISMS            | S T A T I O N S |     |     |     |     |                          |        |        |       |   |
|----------------------|-----------------|-----|-----|-----|-----|--------------------------|--------|--------|-------|---|
|                      | CHENA RIVER     |     |     |     |     | CHENA RIVER TRIBUTARIES* |        |        |       |   |
|                      | 200             | 500 | 600 | 800 | 900 | LC-100                   | NF-100 | SF-100 | M-100 |   |
| Diptera              |                 |     |     |     |     |                          |        |        |       |   |
| Tipulidae            |                 |     |     |     |     |                          |        |        |       |   |
| Tipula sp.           |                 |     | X   | X   |     | X                        | X      | X      | X     |   |
| Dicronota sp.        |                 | X   | X   | X   |     | X                        | X      | X      |       |   |
| Chironomidae         |                 |     |     |     | X   | X                        |        |        | X     |   |
| Cardiocladius sp. A. | X               | X   | X   | X   |     |                          |        |        |       |   |
| Cardiocladius sp. B. | X               |     |     |     |     |                          |        |        |       |   |
| Cricotopus sp.       |                 | X   | X   | X   |     | X                        |        |        | X     |   |
| Trichocladius sp.    |                 |     |     |     | X   | X                        |        |        |       |   |
| Psectrocladius sp.   |                 |     |     |     |     |                          | X      | X      | X     |   |
| Orthocladius sp.     |                 |     |     |     |     |                          |        |        |       |   |
| Smittia sp.          | X               |     |     |     |     | X                        | X      | X      | X     |   |
| Tanytarsus sp. A.    |                 | X   | X   | X   | X   |                          |        |        |       |   |
| Tanytarsus sp. B.    |                 | X   |     | X   |     |                          | X      |        |       |   |
| Metriocnemus sp. A.  | X               |     |     | X   |     |                          |        |        |       |   |
| Metriocnemus sp. B.  |                 |     |     | X   |     | X                        |        |        |       |   |
| Metriocnemus sp. C.  |                 |     | X   | X   | X   | X                        |        | X      |       |   |
| Cardiocladius sp. C. |                 |     |     |     |     |                          |        |        |       |   |
| Rhagionidae          |                 |     |     |     |     |                          | X      |        |       | X |
| Atherix sp.          |                 |     | X   | X   |     |                          |        |        |       |   |
| Dolichopodidae       |                 |     |     |     |     |                          |        |        |       |   |
| Dolichopus sp.       | X               |     |     | X   |     |                          |        |        |       |   |
| Tabanidae            |                 |     |     |     |     |                          |        | X      |       |   |
| Haematopota sp.      |                 |     |     |     |     |                          |        |        |       |   |
| Psychodidae          |                 |     |     |     |     |                          |        |        |       |   |
| Pericoma sp.         |                 |     |     |     |     | X                        |        |        |       |   |
| Telmatoctopus sp.    |                 |     |     |     |     | X                        |        |        |       |   |
| Hemiptera            |                 |     |     |     |     |                          |        |        |       |   |
| Corixidae            |                 |     |     |     |     |                          |        |        |       |   |
| Dasycoreixa sp.      |                 |     |     |     |     |                          |        |        |       |   |
| GROUP FREQUENCY      | 16              | 11  | 22  | 26  | 17  | 17                       | 18     | 18     | 22    |   |

\* LC-Little Chena; NF-North Fork; SF-South Fork; M-Middle Fork



TABLE 22

QUALITATIVE DATA OF SOME BENTHIC ORGANISMS  
FROM SEVERAL STATIONS ON THE CHENA RIVER--1967

|                            | STATIONS AND DATES |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |
|----------------------------|--------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
|                            | 200                |           | 300       |           | 400       |           | 500       |           | 600       |           | 700       |           | 800       |           | 900       |           |
|                            | July 1967          | Sept 1967 | July 1967 | Sept 1967 | July 1967 | Sept 1967 | July 1967 | Sept 1967 | July 1967 | Sept 1967 | July 1967 | Sept 1967 | July 1967 | Sept 1967 | July 1967 | Sept 1967 |
| Oligochaetes               |                    |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |
| Naididae                   | X                  | X         | X         |           |           |           |           |           |           |           |           |           | X         |           |           |           |
| Hydracarina                |                    |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |
| Lebertiidae                |                    |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |
| <u>Lebertia</u> sp.        | X                  |           |           |           |           |           |           |           |           |           | X         |           |           |           |           |           |
| Plecoptera                 |                    |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |
| Brachyptera sp.            |                    |           |           |           |           |           |           |           |           |           | X         |           | X         |           |           |           |
| <u>Isoperla signata</u>    | X                  |           | X         | X         |           |           | X         |           |           |           | X         |           | X         |           | X         |           |
| <u>Alloperia</u> sp.       |                    |           |           |           |           |           |           |           | X         |           | X         |           | X         |           | X         |           |
| <u>Nemoura venosa</u>      |                    |           |           |           |           |           |           |           |           |           |           |           |           |           | X         |           |
| Ephemeroptera              |                    |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |
| <u>Ephemerella</u> sp.     | X                  | X         | X         | X         |           |           | X         |           | X         | X         | X         |           | X         | X         | X         | X         |
| <u>Pseudocloeon</u> sp.    |                    |           |           |           |           |           |           |           |           |           |           |           | X         |           | X         |           |
| <u>Ameletus</u> sp.        |                    |           |           |           |           |           |           |           |           |           |           |           | X         |           |           |           |
| <u>Centropilum</u> sp.     | X                  | X         |           | X         |           |           |           |           |           |           |           |           |           |           |           |           |
| <u>Baetis</u> sp.          |                    |           |           |           |           |           |           |           |           |           | X         |           |           |           |           |           |
| Trichoptera                |                    |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |
| <u>Limnephilus</u> sp.     |                    |           |           |           |           |           | X         |           | X         |           |           |           | X         |           | X         |           |
| <u>Ecclisomyia</u> sp.     |                    |           |           |           |           |           |           |           |           |           |           |           |           |           | X         |           |
| <u>Pycnopsyche</u> sp.     | X                  |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |
| <u>Hesperophylax</u> sp.   | X                  |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |
| <u>Micrasema</u> sp.       |                    |           |           |           |           |           | X         |           |           |           |           |           |           |           |           |           |
| <u>Agapetus</u> sp.        |                    |           |           | X         |           |           |           |           |           |           |           |           |           |           |           |           |
| Diptera                    |                    |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |
| Tipulidae                  |                    |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |
| <u>Tipula</u> sp.          |                    |           |           |           |           |           |           |           |           |           | X         |           |           |           | X         |           |
| Simuliidae                 |                    |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |
| <u>Simulium vittatum</u>   |                    |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |
| <u>Prosimulium ursinum</u> | X                  |           |           | X         |           |           |           |           |           |           |           |           | X         |           | X         |           |
| Chironomidae               |                    |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |
| <u>Prodiamesa</u> sp.      |                    |           | X         |           |           |           |           |           | X         |           |           |           |           |           |           |           |
| <u>Metriocnemus</u> sp.    | X                  |           |           |           |           |           |           |           | X         |           | X         |           |           |           |           |           |
| <u>Cardiocladius</u> sp.   |                    |           |           |           |           |           |           |           |           |           |           |           | X         |           | X         |           |
| <u>Smittia</u> sp.         | X                  |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |
| <u>Brillia</u> sp.         | X                  |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |
| <u>Psectrocladius</u> sp.  | X                  | X         |           |           |           |           |           |           |           |           |           |           | X         | X         | X         | X         |
| <u>Tanytarsus</u> sp.      |                    |           | X         |           |           |           |           |           |           |           |           |           |           |           |           |           |
| Rhagionidae                |                    |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |
| <u>Atherix</u> sp.         | X                  |           |           |           |           |           |           |           |           |           |           |           |           |           | X         | X         |
| GROUP FREQUENCY            | 13                 | 4         | 5         | 5         |           |           | 4         |           | 5         | 1         | 8         |           | 9         | 4         | 11        | 4         |

TABLE 23

QUALITATIVE DATA OF SOME BENTHIC ORGANISMS  
FROM SEVERAL STATIONS ON THE CHENA RIVER - 1968

| ORGANISMS              | STATIONS AND DATES |           |            |           |            |           |            |           |            |           |            |           |            |           |
|------------------------|--------------------|-----------|------------|-----------|------------|-----------|------------|-----------|------------|-----------|------------|-----------|------------|-----------|
|                        | 200                |           | 300        |           | 400        |           | 500        |           | 600        |           | 700        |           | 800        |           |
|                        | April 1968         | Sept 1968 | April 1968 | Sept 1968 | April 1968 | Sept 1968 | April 1968 | Sept 1968 | April 1968 | Sept 1968 | April 1968 | Sept 1968 | April 1968 | Sept 1968 |
| Oligochaetes           |                    | x         |            |           |            |           |            | x         |            |           |            |           |            |           |
| Euchytraeidae          |                    |           |            |           |            |           |            |           |            |           |            |           |            |           |
| Naididae               | x                  | x         |            |           |            |           |            |           |            |           |            |           |            |           |
| Hydracarina            |                    |           |            |           |            |           |            |           |            |           |            | x         |            |           |
| Arrenus sp.            |                    | x         |            | x         |            |           |            | x         |            | x         |            | x         |            |           |
| Plecoptera             |                    |           |            |           |            |           |            |           |            |           |            |           |            |           |
| Isoperla signata       |                    | x         |            | x         |            | x         |            | x         |            | x         | x          | x         | x          | x         |
| Paraperla sp.          |                    |           |            |           |            | x         |            |           |            |           |            |           | x          |           |
| Nemoura sp.            |                    |           |            |           |            | x         |            |           |            |           |            |           | x          |           |
| Alloperla sp.          |                    |           |            |           |            |           |            |           |            |           |            |           | x          |           |
| Ephemeroptera          |                    |           |            |           |            |           |            |           |            |           | x          |           |            |           |
| Ephemerella infrequens | x                  | x         | x          |           |            | x         |            | x         |            | x         | x          | x         | x          | x         |
| Heptagenia sp.         |                    | x         |            |           |            | x         |            |           |            | x         | x          | x         | x          |           |
| Pseudocloeon sp.       |                    | x         |            |           |            | x         |            |           |            | x         | x          | x         | x          | x         |
| Ironodes sp.           |                    |           |            |           |            | x         |            |           |            |           |            |           |            |           |
| Ameletus sp.           |                    | x         |            | x         |            | x         |            |           |            |           |            |           |            |           |
| Trichoptera            |                    |           |            |           |            | x         |            |           |            | x         | x          |           |            |           |
| Limnephilus sp.        |                    | x         |            | x         |            |           |            | x         |            | x         |            | x         | x          |           |
| Pycnopsyche sp.        |                    |           |            |           |            |           |            |           |            |           |            | x         |            |           |
| Ptilostomis sp.        |                    |           |            | x         |            |           |            |           |            | x         |            | x         |            |           |
| Lepidostoma sp.        |                    |           |            |           |            |           |            |           |            |           |            | x         |            |           |
| Agraylea sp.           |                    | x         |            |           |            |           |            | x         |            | x         |            | x         |            |           |
| Brachycentrus sp.      |                    |           |            |           |            | x         |            |           |            |           |            |           |            |           |
| Diptera                |                    |           |            |           |            |           |            |           |            |           |            |           |            | x         |
| Tipulidae              |                    |           |            |           |            |           |            |           |            |           |            |           |            |           |
| Prionocera sp.         |                    |           |            |           |            | x         |            |           |            |           |            |           |            |           |
| Simuliidae             |                    |           |            |           |            |           |            |           |            |           |            |           |            |           |
| Prosimulium sp.        |                    |           | x          |           |            |           |            |           |            |           |            |           |            |           |
| Chironomidae           |                    |           |            |           |            |           |            | x         |            |           | x          |           | x          | x         |
| Cardiocladius sp.      |                    |           | x          |           |            |           |            |           |            |           |            |           |            |           |
| Psectoclaadius sp.     |                    | x         |            | x         |            |           |            | x         |            | x         | x          | x         | x          | x         |
| Tanytarsus sp.         |                    |           |            |           |            |           |            |           |            |           |            |           | x          |           |
| Smittia sp.            |                    | x         | x          |           |            |           |            | x         |            | x         |            | x         | x          |           |
| Brillia sp.            |                    | x         |            | x         |            |           |            |           |            | x         | x          | x         | x          |           |
| Cricotopus sp.         |                    | x         | x          | x         |            |           |            |           |            |           |            | x         |            | x         |
| Tricocladius sp.       |                    |           | x          | x         |            | x         |            |           |            |           |            |           |            |           |
| Ortocladius sp.        |                    | x         |            |           |            | x         |            | x         |            | x         |            | x         |            |           |
| Pentaneura sp.         | x                  |           |            |           |            |           |            |           |            |           |            |           |            | x         |
| Diamesa longimanus     | x                  | x         | x          | x         |            |           |            |           |            |           |            |           |            |           |

Table 23 Cont.

| ORGANISMS                    | STATIONS AND DATES |           |            |           |            |           |            |           |            |           |            |           |            |           |
|------------------------------|--------------------|-----------|------------|-----------|------------|-----------|------------|-----------|------------|-----------|------------|-----------|------------|-----------|
|                              | 200                |           | 300        |           | 400        |           | 500        |           | 600        |           | 700        |           | 800        |           |
|                              | April 1968         | Sept 1968 | April 1968 | Sept 1968 | April 1968 | Sept 1968 | April 1968 | Sept 1968 | April 1968 | Sept 1968 | April 1968 | Sept 1968 | April 1968 | Sept 1968 |
| <u>Prodiamesa bathuphila</u> |                    |           |            |           |            | x         |            |           |            |           |            |           |            |           |
| <u>Polypedilum</u>           |                    | x         |            |           |            | x         |            |           |            |           |            |           |            |           |
| <u>Metriocnemus</u> sp.      |                    | x         |            | x         |            |           |            |           |            | x         |            | x         |            |           |
| <u>Metriocnemus</u> sp.      |                    |           |            | x         |            |           | x          |           |            | x         |            | x         |            |           |
| <u>Microspectra</u> sp.      |                    | x         |            | x         |            |           |            |           |            |           |            |           |            | x         |
| Rhagionidae                  |                    |           |            |           |            |           |            |           |            |           |            |           |            |           |
| <u>Atherix</u> sp.           |                    |           |            |           |            |           | x          |           | x          |           |            |           | x          |           |
| Ceratopogonidae              |                    | x         |            |           |            |           |            |           |            |           |            |           |            |           |
| Halipidae                    |                    |           |            |           |            | x         |            |           |            |           |            |           |            |           |
| Tetanoceridae                |                    |           |            |           |            |           | x          |           | x          |           |            | x         |            |           |
| Dolicopodidae                |                    | x         |            |           |            |           |            |           |            |           |            |           |            |           |
| Psycodidae                   |                    |           |            |           |            |           |            |           |            | x         |            | x         |            |           |
| Hemipter                     |                    |           |            |           |            |           |            |           |            |           |            |           |            |           |
| Corixidae                    |                    |           |            | x         |            | x         | x          |           | x          |           | x          | x         | x          | x         |
| GROUP FREQUENCY              | 2                  | 22        | 6          | 14        |            | 14        |            | 14        |            | 17        | 9          | 18        | 14         | 11        |

Table 22 show that there has been a still further reduction from the samples collected in July. Station 200 was represented by four groups, 300 by five groups, 600 by one group, 800 by four groups, and 900 by four groups.

When these variations became apparent, plans were made to sample the areas in the spring prior to breakup to determine whether there was a further reduction or whether there was re-establishment of organisms during the winter. This was a very difficult series to collect since weather conditions are very severe and not all sampling sites lend themselves to winter sampling. As a result, samples were not collected from stations 400, 500, and 600. The only stations that showed any great change from the September sampling period were 200 and 800 (Table 22). It is difficult to explain why only earthworms and one mayfly were represented in the 200 sample because, from all appearances, the sampling sites were ideal. The increase from four groups in September 1967 to fourteen groups in April 1968 at station 800 was probably a re-establishment of the population since this area was extremely eroded during the flood and had time to stabilize by April.

A final series of samples was taken in September 1968 to establish whether the populations were back to pre-flood levels. This collection pointed out the ability of a stream to recover from a disaster. Station 200 contained 22 taxonomic groups, 300 had 14 groups, 400 had 14 groups, 500 had 14 groups, 600 had 17 groups, and 800 had 11 groups. Although these numbers are not as large as those of August 1966, the diversity is typical of a healthy stream. Figure 14 summarizes these five sets of data.

In July 1967 and August 1968 (Table 24), quantitative samples of riffle organisms were collected. In a river such as the Chena, the riffle areas are the habitat of more invertebrates than are commonly found elsewhere. Most of the fish food organisms are found in these areas, and as a result, anything which might change the ratio of pool to riffle area would also have an effect on the productivity and the total population.

The riffle organisms can be conveniently separated into five important groups which would cover more than 90 percent of the animals present. These groups are annelids (Oligochaeta), stoneflies (Plecoptera), mayflies (Ephemeroptera), caddisflies (Trichoptera), and flies (Diptera). Not only are these organisms important in the food chain, but they are also excellent indicators of changes in the environment. These five very important groups dominated the riffle fauna of the Chena; therefore, the quantitative data for 1967 and 1968 were arranged utilizing this grouping.

The quantitative data presented consists of the average of three Surber samples collected from riffles consisting of large rubble and gravel. Both the 1967 and 1968 samples were collected from the same riffle when possible. The data is presented as numbers of organisms per square foot (Table 24)

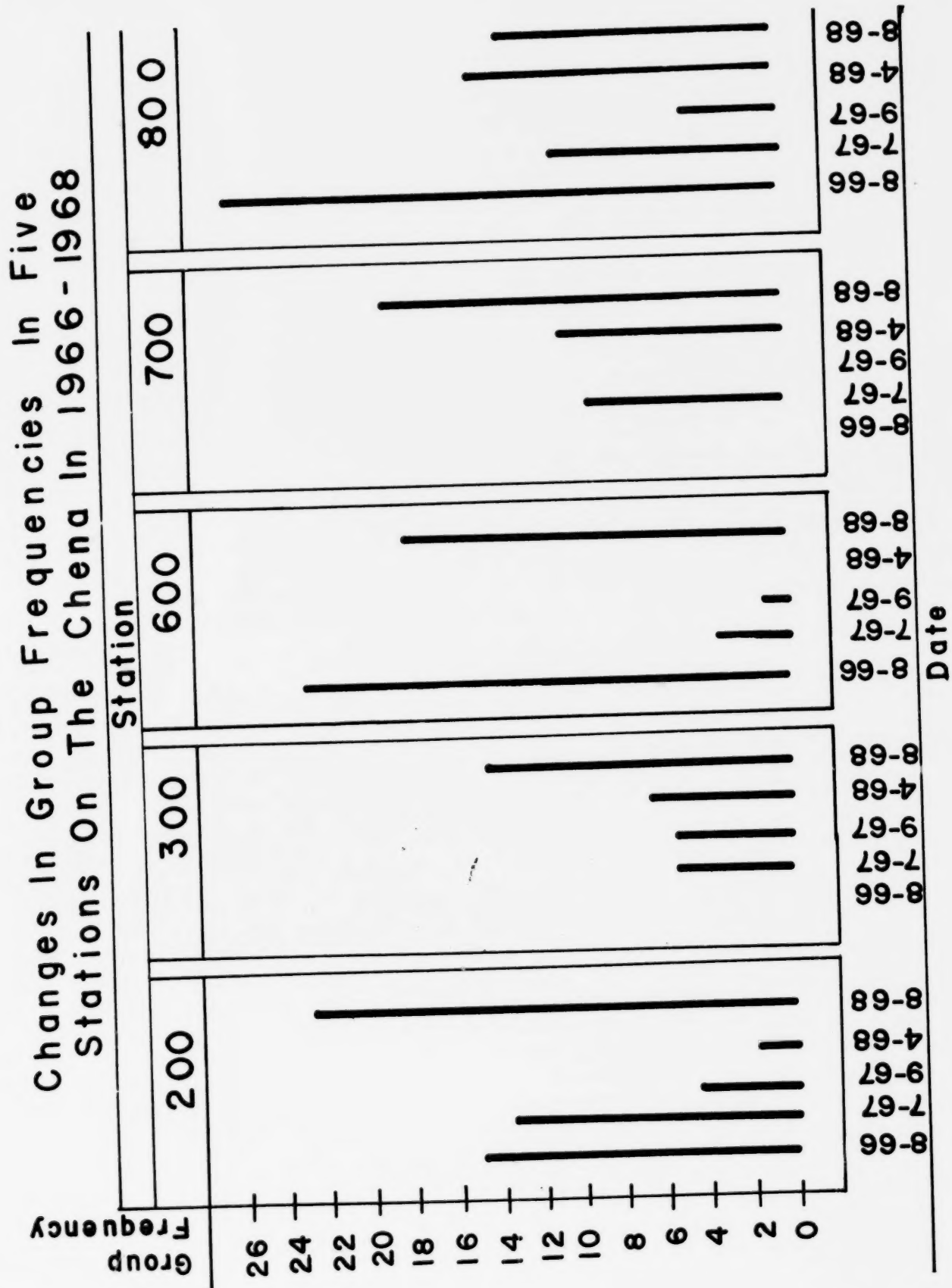


Figure 14



TABLE 24  
NUMBER AND PERCENTAGE OF ORGANISMS FOUND PER SQUARE FOOT FROM SEVERAL STATIONS ON THE CHENA RIVER

JULY 1967

|               |       | S T A T I O N S |       |       |        |       |        |       |       |       |       |       |       |       |       |       |       |       |       |
|---------------|-------|-----------------|-------|-------|--------|-------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 100           |       | 200             |       | 300   |        | 400   |        | 500   |       | 600   |       | 700   |       | 800   |       | 900   |       |       |       |
| 1*            | 2**   | 1               | 2     | 1     | 2      | 1     | 2      | 1     | 2     | 1     | 2     | 1     | 2     | 1     | 2     | 1     | 2     |       |       |
| 49.6          | 55.6  | 25.7            | 5.0   | ----- | -----  | ----- | -----  | ----- | 0.3   | 0.2   | ----- | ----- | ----- | ----- | ----- | ----- | ----- |       |       |
| Oligochaeta   | ----- | -----           | ----- | ----- | -----  | 5.7   | 0.2    | 1.0   | 0.1   | 2.3   | 1.2   | 5.3   | 4.0   | 13.3  | 45.8  | 22.0  | 25.5  | 6.0   | 0.3   |
| Plecoptera    | 1.0   | 1.1             | 9.3   | 1.8   | 5.2    | 172.7 | 5.2    | 74.0  | 3.5   | 14.3  | 7.6   | 26.7  | 19.8  | 3.7   | 12.8  | 13.3  | 15.5  | 35.7  | 45.8  |
| Ephemeroptera | ----- | -----           | 0.7   | 0.1   | 3.3    | 0.1   | 1.7    | 0.1   | ----- | ----- | ----- | 2.7   | 2.0   | ----- | ----- | ----- | ----- | ----- | ----- |
| Trichoptera   | 38.6  | 43.3            | 486.3 | 93.1  | 3126.0 | 94.5  | 2066   | 96.3  | 171.0 | 91.0  | 100.3 | 74.2  | 12.0  | 41.4  | 50.7  | 59.0  | 36.0  | 46.2  | ----- |
| Diptera       | 89.2  | 100             | 521.7 | 100   | 3307.7 | 100   | 2142.7 | 100   | 187.9 | 100   | 135   | 100   | 29    | 100   | 86    | 100   | 78    | 100   | ----- |
| TOTAL         |       |                 |       |       |        |       |        |       |       |       |       |       |       |       |       |       |       |       |       |

AUGUST 1968

|               |       |       |       |      |       |      |       |      |       |      |      |      |       |      |       |      |       |       |       |
|---------------|-------|-------|-------|------|-------|------|-------|------|-------|------|------|------|-------|------|-------|------|-------|-------|-------|
| Oligochaeta   | ----- | ----- | 9.7   | 2.0  | 80.3  | 21   | 280.3 | 47.5 | 3.0   | 0.6  | 8.3  | 17.4 | 5.0   | 2.5  | 8.7   | 4.5  | ----- | ----- | ----- |
| Plecoptera    | ----- | ----- | 3.7   | 0.80 | 1.7   | 0.5  | 9.7   | 1.6  | 0.3   | 0.1  | 2.3  | 4.8  | 40.5  | 20.4 | 54.3  | 28.0 | ----- | ----- | ----- |
| Ephemeroptera | ----- | ----- | 45.3  | 10.0 | 21.0  | 6.0  | 66.0  | 11.2 | 11.3  | 2.1  | 12.3 | 25.8 | 22.5  | 11.3 | 27.7  | 14.3 | ----- | ----- | ----- |
| Trichoptera   | ----- | ----- | 1.0   | 0.20 | 0.7   | 0.2  | 2.7   | 0.5  | 2.0   | 0.4  | 17.7 | 37.2 | 2.5   | 1.3  | 2.0   | 1.0  | ----- | ----- | ----- |
| Diptera       | ----- | ----- | 391.3 | 87.0 | 272.0 | 72.3 | 230.7 | 39.2 | 511.3 | 96.8 | 7.0  | 14.8 | 128.5 | 64.5 | 101.3 | 52.2 | ----- | ----- | ----- |
| TOTAL         | ----- | ----- | 451.0 | 100  | 375.7 | 100  | 589.4 | 100  | 527.9 | 100  | 47.6 | 100  | 199.0 | 100  | 194.0 | 100  | ----- | ----- | ----- |

1\* Number per square foot  
2\*\* Percentage

In both 1967 and 1968, highest numbers tended to be in stations in the lower river. In 1967, large numbers of dipterans were collected at stations 300 and 400, which raised the total number of these stations out of proportion. Aside from that, numbers were fairly comparable between stations for the two years. In virtually every sample, the dipterans dominated in numbers. The steady increase of stoneflies from the mouth to the headwaters is of special ecological interest. Although mayflies exhibited the same trend, there were some variations. Dipterans and annelids, on the other hand, exhibited a downward trend as the headwaters were approached. The caddisflies contributed an insignificant amount at all times at all stations except station 600, where they represented 37 percent the total number present. This high percentage was due to the very small number of organisms collected at that station, making the 12 caddisflies a large portion of the total collection.

#### Annelids (Oligochaeta)

Annelids feed on and effectively mix the bottom soil of the stream beds. Temperature is not usually a limiting factor, but may determine the relative abundance and specialization of oligochaetes. The enchytraeids are notable because they are usually found in cold mountain streams originating from snow banks or glaciers; some species of *Aeolosoma* encyst when the temperature drops to 6°C. Tubificids are the dominant forms in depths exceeding one meter and the most concentrated populations are found in streams that are polluted with sewage. Most species are able to thrive in areas of low dissolved oxygen, and some are able to withstand complete absence of oxygen for extended periods of time (Penak, 1953).

Enchytraeids in the upper reaches of the river were found and naidides in the lower river. Tubificids were not found at any station.

#### Stoneflies (Plecoptera)

Stoneflies are terrestrial insects, but seldom found far from running water, which is the habitat of the immature stages. Many species are quite specific in their ecological preferences. Some occur only in small brooks, while others inhabit only large, slow-moving rivers. Some are found only in pools, while others occur only in swift currents. Hynes (1941) lists five major factors as controlling the distribution of stonefly nymphs:

1. Water movement.
2. Altitude--as it regulates temperatures.
3. Substrate.

4. Drought--in relation to the length of nymphal life.
5. Proximity of habitats in which stoneflies are abundant.

Although the stoneflies are one of the smaller orders of insects, they are a very important group in streams such as the Chena, where they are one of the principal sources of food for grayling and whitefish. Because of their preference for clean, well-oxygenated water, the stoneflies are also becoming important as indicators of clean water conditions.

The stoneflies were represented by at least nine species in the Chena River. Of special interest were the stoneflies found at station 100. As earlier stated, stoneflies are usually found in highly oxygenated water. Certain species, however, seem to be more tolerant of low dissolved oxygen. Brink (1949) reports stoneflies in water 40 percent saturated with oxygen and, Gaufin (1963) reports a stonefly captured in the Great Miami River, where dissolved oxygen dropped to 5 mg/l at night. However, the dissolved oxygen at station 100 drops to less than 2 mg/l, and there was still a good population of Brachyptera and Isoperla sp. present. The reason the organisms were able to survive was probably that the low dissolved oxygen, even though extended in duration, occurred when the water was at 0°C and metabolic activities were at a very low rate.

#### Mayflies (Ephemeroptera)

Mayflies can be found in almost all freshwater environments, from the tropics to the arctic and from sea level to above timberline (Leonard, 1963). Like the stoneflies, they are terrestrial as adults but spend their nymphal life in the water. These aquatic stages vary from a few months to several years depending on species and geographic location. The nymphs may occur in lakes to depth of 15 meters or more, but generally they are associated with shallow water. The species appear to be somewhat specific to substrate. Some appear only on vegetation, some only on mud, debris, gravel or rock bottoms, and some burrow (Pennak, 1953).

Although mayfly nymphs will show the effect of pollution, it is often difficult to account for wide disparity in quantitative mayfly production from two areas that are very similar in their chemical and physical characteristics (Leonard, 1963).

The mayflies were represented by at least 12 species in the Chena River and were present at all sampling stations (Table 22).

#### Caddisflies (Trichoptera)

The caddisflies are an interesting group of insects because a large portion of them are case builders. The adult is terrestrial, but the larvae are

aquatic and are rather cosmopolitan in their distribution. These larval forms are divided into two groups: campodeiform, which usually do not have a case (if they do, it is not portable), and the eruciform, which usually have a portable case. The case may consist of sand grains, gravel, small pieces of leaves, grass, bark or twigs. Most larvae move actively in search of food, but those that build nets simply remove the plant and animal material that collects in their nets (Pennak, 1953).

Generally, the caddisfly larvae are tolerant of a wide range of chemical factors (Rogach, 1962). Although some species are tolerant of low dissolved oxygen levels, the caddisflies are not very well represented in the lower reaches of the Chena River, which are usually subjected to low dissolved oxygen in the winter. Robach (1963) reports that the caddisflies formed 8-13 percent of the insect population of river studies, but they accounted for less than 1 percent in most stations in the Chena.

### Dipterans (Diptera)

This is a large group of insects which includes such common flies as houseflies, mosquitoes, crane flies, midges, horseflies, and snipe flies. In the Chena River, the only groups of real importance are the midges and blackflies. The midges (Chironomidae) are a very complex family of about 3,000 described species of worldwide distribution. The adult is terrestrial while the larvae is aquatic. The duration of the life cycle is variable; some have only one generation in two years, while others have several (Pennak, 1953).

Some species are solitary while others occur in vast numbers, especially in lakes. The degree of tolerance to dissolved oxygen varies from anaerobic to near saturation. Because of this, it is difficult to use midges as indicator organisms, especially since taxonomists do not fully agree on their classification. The differences between genera are small and variations within species are large.

The blackflies or buffalo gnats (Simuliidae) are a small family whose adults again are terrestrial, but whose larval forms are aquatic. The larvae are found in the shallows of streams where the current is swift. Sometimes they are so abundant that they obscure the bottom. These insects find their importance in the adult stage, when at times, they appear in such great numbers as to be almost unbearable. The female has an irritating bite, especially on campers, hunters and fishermen who are particularly well acquainted with them (Pennak, 1953). Blackflies may be well suited as indicators of toxic substances, especially DDT, which apparently paralyzes their holdfast organs and causes them to be dislodged and swept with the current (Cope, 1957).



## Bacteria

The effects of sewage pollution from the Fort Wainwright-Fairbanks area is a major concern in the present analysis of the Chena River. When this study was initiated, only scattered information was available on the coliform status in the river below Fairbanks. At that time, the total population of the area was approximately 58,000 people, who added approximately 3-million gallons of sewage to the river daily. Most of this sewage received primary treatment, a small amount had secondary treatment, and a considerable volume was untreated. To determine the coliform count in the Chena River, a sampling schedule was initiated, testing three stations weekly in the polluted zone and one above the polluted zone. Of these stations, 100 at Pikes Landing included all pollution, 200 included all but College Utilities, 300 included only Fort Wainwright, and 600 was above all the metropolitan sources of pollution. This particular study was started in May 1966 and was concluded in October 1968. The bacteriological assay of the coliform bacteria was determined by the Membrane Filter Technique from Standard Methods, 12th Ed., 1965.

The coliform numbers from stations 100, 200 and 300, shown in Table 25, are characteristic of a stream polluted by sewage. The Chena River, above station 600, has a small resident population, but the Chena Hot Springs highway follows closely along the river affording access to the popular grayling fishing spots. The coliform content of the upper river can be attributed to indigenous animals, sport fishermen, picnic groups and transient campers. Bacteria are the decomposers in the ecosystem and are always a factor in any consideration of water quality. The concern with the coliform bacteria is that they indicate fecal pollution from warm blooded animals, and, as such, indicate the possible presence of water-borne pathogenic organisms. The technique of determining the coliform count makes use of a selective culture medium in which the nonfecal organisms are screened out. A total bacteria count on a non-selective culture medium will include all the facultative and obligate aerobic organisms in the environment under the same temperature regime. If some of the bacteria are obligate psychrophiles, they will be inhibited at the temperature of 30°C at which the total coliforms are incubated.

The non-selective medium was prepared according to the following formula:

Bacto-yeast extract 5g.

Bacto-tryplone 10g.

Bacto-dextrose 2 g.

Distilled water 2 l.

The pH was adjusted to 7.0 at 25°C before autoclaving. River water samples were diluted with a sterile phosphate buffered water to a satisfactory counting level and plated using the membrane filter technique. One series of plates was incubated at 35°C in a humidified tray, and the other was incubated near the ambient temperature of the water at the time of taking the



TABLE 25

AVERAGE MONTHLY TOTAL COLIFORMS PER 100 ML  
FROM FOUR STATIONS ON THE CHENA RIVER

| DATE           | S T A T I O N S |         |         |                 |
|----------------|-----------------|---------|---------|-----------------|
|                | Polluted Area   |         |         | Unpolluted Area |
|                | 100             | 200     | 300     |                 |
|                |                 |         |         | 600             |
| May 1966       | 6,700           | 5,800   | 5,800   | --              |
| June 1966      | 15,800          | 9,200   | 3,900   | --              |
| July 1966      | 30,000          | 37,300  | 17,800  | 9               |
| August 1966    | 259,200         | 377,400 | 107,800 | 13              |
| September 1966 | 397,500         | 270,000 | 67,500  | 3               |
| October 1966   | 236,800         | 323,300 | 212,800 | 5               |
| November 1966  | 169,200         | 306,000 | 218,000 | 1               |
| December 1966  | 156,800         | 149,500 | 166,300 | 0               |
| January 1967   | 140,000         | 190,000 | 222,500 | 0               |
| February 1967  | 138,600         | 225,000 | 222,000 | 1               |
| March 1967     | 207,500         | 182,500 | 252,500 | 0               |
| April 1967     | 126,000         | 187,500 | 247,500 | 20              |
| May 1967       | 41,800          | 47,600  | 44,000  | 9               |
| September 1967 | 23,200          | 27,000  | 21,900  | 7               |
| October 1967   | 57,100          | 70,400  | 82,000  | 5               |
| November 1967  | 149,700         | 152,000 | 122,000 | 2               |
| December 1967  | 122,800         | 171,900 | 178,800 | 3               |
| January 1968   | 214,700         | 254,400 | 230,500 | 10              |
| February 1968  | 149,200         | 206,700 | 265,000 | 3               |
| March 1968     | 171,700         | 220,400 | 216,400 | 2               |
| April 1968     | 177,300         | 446,300 | 556,200 | 11              |
| May 1968       | 32,300          | 160,000 | 84,700  | 11              |
| June 1968      | 37,700          | 33,400  | 76,200  | 10              |
| July 1968      | 353,300         | 160,400 | 146,600 | 22              |
| August 1968    | 263,300         | 209,100 | 187,300 | 31              |
| October 1968   | 322,900         | 421,100 | 365,000 | 6               |

samples. The cultures were continued until there was no increase in numbers of colonies; for the 0-10°C series, this was over 2 months. Table 26 presents the data from the three series of cultures. The total coliform counts are slightly lower than comparative counts in the 100, 200, and 300 areas.

The numbers of colonies reported in 0-10°C column are of importance; they show that there are a very considerable number of bacteria that grow under the environmental temperature conditions found in the Chena River, and which will have significant influence on the winter dissolved oxygen.

The bacteria capable of growth at low temperatures probably include some autochthonous individuals, but most are facultative mesophiles that have adapted to the environment. Within the sewage polluted area, the Gram positive cocci and bacilli are approximately 5 to 15 percent of the total flora. In winter, low temperature of the water prevents the Chena River from becoming septic in the short distance it flows through the polluted area.

### Fisheries

The Chena River provides habitat for a number of fish species. In the upper reaches of the river, the arctic grayling (Thymallus arcticus) and round whitefish (Prosopium cylindraceum) are the predominant species. In addition to these two species, the lower portions of the river also contain populations of northern pike (Esox lucius), northern sucker (Catostomus catostomus), burbot (Lota lota leptura), and lesser numbers of other species. King salmon (Oncorhynchus tshawytscha), chum salmon (O. keta) and sheefish (Stenodus leucichthys) also migrate into the river. A list of other fish species known to occur in the Chena River follows:

Brook lamprey  
Humpback whitefish  
Least cisco  
Slimy sculpin

Lampetra lamottei  
Coregonus pidschian  
Coregonus sardinella  
Cottus cognatus

Because

Because of its proximity to Fairbanks and the easy access provided by the Chena Hot Springs Road, the Chena River is the most popular and intensively utilized sport fishing stream of Interior Alaska. The principal fish sought by anglers is the arctic grayling.

The Alaska Department of Fish and Game, Sport Fisheries Division, has conducted intensive creel census studies on the river for several years. In 1968, the summer angler utilization in the Chena Hot Springs Road and Chena Slough areas was calculated at 24,374 angler hours (Roguski and Winslow, 1969). As considerable angling also takes place at other locations on the river, this is probably not more than half of the total yearly angling effort for the entire Chena system.

TABLE 26

TOTAL BACTERIA COUNTS FROM WINTER, SUMMER AND FALL  
AT NINE STATIONS ON THE CHENA RIVER

| STATION | TOTAL<br>DATE | TOTAL COLIFORM<br>Per 100 ml | TOTAL BACTERIA COUNTS PER ML |                   |
|---------|---------------|------------------------------|------------------------------|-------------------|
|         |               |                              | 35°C Incubation              | 0-10°C Incubation |
| 100     | Jul/5/67      | 36,000                       | -----                        | 9,000             |
|         | Jul/18/67     | -----                        | 11,500                       | 29,000            |
|         | Sep/25/67     | 62,900                       | 4,375                        | 3,500             |
|         | Apr/11/68     | 133,300                      | 22,000                       | 11,000            |
| 200     | Jul/5/67      | 34,000                       | -----                        | -----             |
|         | Jul/18/67     | -----                        | 5,200                        | 8,400             |
|         | Sep/25/67     | 37,100                       | 2,875                        | 2,875             |
|         | Apr/11/68     | 183,300                      | 26,800                       | 9,800             |
| 300     | Jul/5/67      | 42,000                       | -----                        | 16,000            |
|         | Jul/18/67     | -----                        | -----                        | -----             |
|         | Sep/25/67     | 38,700                       | -----                        | 3,500             |
|         | Apr/11/68     | 383,300                      | 52,000                       | 4,280             |
| 400     | Jul/5/67      | 44                           | 175                          | 10,000            |
|         | Jul/18/67     | -----                        | -----                        | -----             |
|         | Sep/25/67     | 16                           | 41                           | 2,625             |
|         | Apr/11/68     | 9                            | 392                          | 1,720             |
| 500     | Jul/5/67      | 15                           | -----                        | 8,000             |
|         | Jul/18/67     | -----                        | 390                          | 7,400             |
|         | Sep/25/67     | 4                            | 34                           | 975               |
|         | Apr/11/68     | 1                            | -----                        | 2,120             |
| 600     | Jul/5/67      | 9                            | -----                        | 6,500             |
|         | Jul/18/67     | -----                        | 34                           | 2,800             |
|         | Sep/25/67     | 5                            | 26                           | 3,625             |
|         | Apr/11/68     | 1                            | -----                        | 1,720             |
| 700     | Jul/5/67      | 24                           | 79                           | 1,800             |
|         | Jul/18/67     | -----                        | 54                           | 5,600             |
|         | Sep/25/67     | 15                           | 120                          | 1,000             |
|         | Apr/11/68     | 1                            | 850                          | 1,280             |
| 800     | Jul/5/67      | 27                           | 74                           | 800               |
|         | Jul/18/67     | -----                        | -----                        | -----             |
|         | Sep/25/67     | 19                           | 6                            | -----             |
|         | Apr/11/68     | 0                            | 128                          | 680               |
| 900     | Jul/5/67      | 10                           | 100                          | 700               |
|         | Jul/18/67     | -----                        | 22                           | 700               |
|         | Sep/25/67     | 8                            | 6                            | 750               |
|         | Apr/11/68     | 1                            | 6                            | 360               |

The grayling catch per angling hour may vary considerably from one year to the next but has remained consistently high for the past 15 years for which records are available. The catch of .96 fish per man hour for 1969 compares closely with the .89 fish per man hour in 1955 and .95 in 1956 (Warner, 1958). Fishing pressure during this period has increased several fold due to rising angler numbers and improved access.

Since 1967, the Sport Fisheries Division has employed a riverboat mounted electro-fishing apparatus for study of grayling populations and their seasonal movements (Van Hulle, 1968). This apparatus consists of a 3KW generator delivering alternating current through a 16-foot wide boom mounted on the front of a riverboat. Grayling captured by this method are either tagged or marked by fin clip.

In 1968, two sections of the lower Chena River were selected by the State Fish and Game Department to determine the population density of the grayling. The approximately 3-mile-long reach from the confluence with the Little Chena River to the mouth of the Chena Slough and the 5 miles of river flowing through Fairbanks from the Wendell Street Bridge to the University Avenue Bridge were studied intensively. The purpose was to select sampling areas on the lower river, both above and below major sources of domestic and industrial pollution. Neither of these reaches is subjected to heavy angler use. In the upper section, the calculated summer population was 452 fish per mile; in the lower section, the calculated mean was 657 fish per mile. These figures include only fish that are 1 year or more in age. It does not appear, from the work of the Fish and Game Department, that pollution in the lower Chena has inhibited the grayling at the present time.

In late fall, grayling leave small headwater tributaries and enter the main Chena. Several years of tagging by the Alaska Department of Fish and Game have failed to reveal any inter-stream movements or evidence that grayling leave the river during winter months. Grayling were observed in the north fork in mid-December 1969 and were caught in considerable numbers through the ice at river mile 25 as early as March 1 in 1967 and 1968.

During 1969 and 1970, the Department of Fish and Game has found spawning grayling from about river mile 80 down to river mile 30. This is the only stretch of river that has been sampled during the spawning period. It is probable that spawning occurs both above and below this section. Spawning begins about May 10 to 15, contingent upon water temperatures reaching 42° to 44°F and is completed by about May 20.

In the Chena River, nearly all grayling are mature at 5 years of age at a mean fork length of 290 mm. In contrast to this late maturity, grayling in some Alaskan lake systems mature at 2 to 3 years of age. In the Chena River, few grayling over 7 years of age have been captured either by anglers or by the Alaska Department of Fish and Game.



Anadromous fish migrate up the Chena River in very small numbers. Kogl, (1965), gives an estimate of 900 chum salmon and 150 king salmon spawning in the Chena River. He reports in detail the spawning of chum salmon in the section of river between 50 and 105 miles. This is an area of numerous small springs and seeps of ground water. The fish deposit their eggs in places where the flow from the spring keeps them aerated and protected from freezing. Spawning takes place in late summer and the eggs hatch during the winter, in January and February.

King salmon spawn in riffle areas throughout a large portion of the upper river.

These two species enter the sport fishery in only limited numbers. Both commercial and subsistence fishing for salmon is prohibited in the Chena to protect these small but important spawning stocks.

#### Whitefish

Round whitefish are found in nearly all reaches of the river and in numbers approximating those of the grayling. However, neither this species nor the less abundant least cisco and humpback whitefish are important in the sport fishery. A recent change in sport fishing regulations allowing the fall spearing of whitefish may increase the utilization of these fish in the Chena and other rivers of the Tanana drainage.

#### Sheefish

Sheefish in Alaska are extending their range in the Tanana drainage. Up to 15 years ago, sheefish had been unheard of in the Chena River. During the past few summers, a minimum of 10-15 sheefish have been caught by sport anglers. All sheefish taken by sport anglers have been taken in the lower 10 miles of the river. It is not known if the sheefish spawn in the Chena but nearly all fish examined by the Fish and Game Department were mature. Sheefish have very stringent spawning ground requirements. This ideal combination of gravel size, current speed, and depth would only be found in a few areas of the Chena in the approximate areas near the Baily Bridge site (mile 60).

As the sheefish population in the Chena increases and with the possibility of future stocking of sheefish fingerlings, this fish may become an important aspect of the Chena River sport fishery.

#### Pike

Small numbers of northern pike are found throughout the lower Chena, Chena Slough and in slough areas of the upper river. The few pike



caught annually are popular with anglers. Pike tagged in the Chena River have been captured in the Nelson Clearwater which is a nearby tributary of the Tanana River

### Suckers

In portions of the lower river, the poundage of suckers is probably greater than that of any other species. In spite of this, suckers have received very little study.

### Burbot

Burbot are present in the lower reaches of the Chena where they are taken during the winter with set lines.

Chen (1969) reports the capture of a number of young burbot in the lower Chena. The Alaska Department of Fish and Game has also captured young burbot, but as yet, it is not known whether burbot actually spawn in the Chena. Burbot spawning occurs in the mid-winter, making difficult the study of reproductive habits.

## SECTION VII

### DISCUSSION

#### River and Basin Description

The data collected in this study characterize the Chena River as a typical free-flowing subarctic river originating in high lands composed of metamorphic rocks, traveling through large areas of marsh and bog, becoming highly enriched by organics from treated and raw domestic sewage, and finally emptying into the larger glacially influenced Tanana River.

Two stream characteristics, flow and water temperature, are important in any consideration of water use and water quality. The discharge pattern of the Chena is typical of snow-melt streams. The low flow generally occurs in February or March which is also the time when dissolved oxygen levels are approaching critical limits. The average March flow of the Chena River at Fairbanks, for the period 1949-1967, was 270.2 cfs. This is in contrast to the average summer (July) flow for the same period of time of 2278.0 cfs. With such low flows during the winter months, the river has very little capacity to dilute and assimilate domestic wastes. The chemical and biological effects of these wastes will be discussed later.

The relationship between water temperature and aquatic life is quite well known. The interrelationships of species, day length, and water temperature, are so intimate that even a small change in water temperature may have far reaching effects. In an artificially warmed stream, for example, a fish might hatch too early in the spring to find an adequate amount of its natural food organisms because the food chain depends ultimately on plants whose abundance, in turn, is a function of day length and temperature.

The Chena River displays a temperature regime that is characterized by a 6-month period of near 0°C, a 6-week period of warming, a 3-month summer period with temperatures from 10°-17°C, and a 6-week period of cooling. The summer conditions are the most critical in terms of possible thermal pollution. As the river flows through the Fairbanks area, heat is introduced through sewage effluents, cooling waters from the Fairbanks Power Plant, and solar radiation. To illustrate the warming that takes place through these influences, the temperature of the river just above Fairbanks on July 25, 1968, was 16.2°C, while the temperature below the city, at the same time, was 17.5°C, an increase of 1.3°C (2.5°F). The State-Federal Water Quality Standards for the "growth and propagation of fish and other aquatic life" require there be no thermal discharge into a stream where ambient water temperatures are above 60°F (15.5°C). This requirement is necessary to protect the cold water fishery. If any appreciable heat load is introduced into a stream, it must be recognized that the species' equilibrium will likely be shifted towards those characteristic of

a more temperate water. In addition to this concern, studies on the arctic grayling (Schallock, 1965) indicate that in the 50°-60°F range, avoidance reactions take place when small water temperature differences (2°F) occur. This means that thermal discharges to the river that raise the temperature by that magnitude can create a thermal block to the movement of the grayling.

The domestic sewage discharge into the Chena River from the Fairbanks area is approximately 3-million gallons per day, with a total biological oxygen demand of about 2,400 pounds per day. This waste load increases the phosphate and chloride concentrations as well as the oxygen demand. To illustrate the oxygen demand increase, from the domestic sewage discharge during the critical winter period, the chemical oxygen demand above Fairbanks on March 7, 1967, was 8.46 mg/l, while the station below Fairbanks showed a chemical oxygen demand of 25.23 mg/l on the same day. The micro- and macrobiology also reflect the influences of heavy domestic pollution. Coliform counts increased at times dramatically from less than 50/100 ml in the upper river to over 500,000/100 ml below Fairbanks.

The utilization of secondary sewage treatment systems for Fairbanks and Fort Wainwright, with effluents discharged to the Chena, would reduce the existing organic waste load by approximately 70 percent. It is doubtful, however, that this reduction would be sufficient to raise the water quality of the Chena river to meet the State Water Quality Standards. If the Chena River is to be restored to a healthy and aesthetically acceptable body of water, municipal and industrial effluents from the Fairbanks area must be discharged outside of the river drainage.

#### Flood Control

At some time in the future, the Chena River will be regulated by a flood control dam. The effects of this regulation on the water quality of the river are not entirely predictable; however, considerable information is available on the effects of impoundments on the waters of a free-flowing stream under more temperate climatic conditions. Some of this information is applicable to Interior Alaska. Churchill (1958), Dendy, and Strant (1949), and Love (1961), among others, discuss the effects of impoundments on downstream water quality. Significant changes can be expected on the lower Chena from the reservoir regulation data that is given. A reduction of maximum stream flows and an increased minimum flow below the impoundment will occur. There should be a reduction in turbidity, silica, color, and variations in dissolved minerals, pH, and alkalinity. The downstream water temperatures are expected to be slightly lower in the summer with little change during the winter months. A serious problem can develop if the impoundment covers the moss-muskeg-forest area. The principal source of organics in the water of the reservoir, under these conditions, will be from the natural organics. Although all impoundments are subjected to this condition to some degree, the stabilization is usually short and the contamination mild. In the case of the Chena, because of the vast amount and nature of the substrate plus the very low annual heat budget, this stabilization time can conceivably be of a much longer duration. The only way to preclude this from happening is to clear the reservoir site down to mineral soil.



Of greater concern is the effect that this impoundment can have on the oxygen regime of the river below the impoundment. Results from studies in other areas show that dissolved oxygen is reduced in many impoundments. The Chena River dam is designed with outlet works that will draw off only the water near the bottom of the reservoir. This water will be lower in dissolved oxygen than the natural river water, both in summer and winter. During the winter months, minimum releases from the impoundment will be 300 cfs. This water will be slightly warmer than the natural stream waters but can be expected to cool rapidly to 0.0°C and develop an ice cover. It is doubtful that there will be sufficient reaeration before an ice cover forms to present a dissolved oxygen level in the river that would be as high as under natural conditions. At the present time, the winter concentrations of dissolved oxygen in the lower river are reaching a threshold level. If the oxygen is reduced still further by the impoundment, it is highly probable that oxygen concentrations will go to zero before water approaches the Fairbanks area. During the summer months, the reservoir releases will be much larger (800 cfs plus). As the discharged water will still be critically low in dissolved oxygen for several miles before natural reaeration, the lower river would be adversely affected with oxygen deficiency during the winter while the upper river below the impoundment would suffer the same fate during the summer. Both conditions are intolerable to the growth and propagation of fish and other aquatic life. However, both conditions could be eliminated by suitable in-stream reaeration devices or variable level outlet works at the dam.

### Chemistry

Silica, nitrogen and phosphorus are the three important nutrients found in the river. Silica concentrations generally increase as the water moves downstream and appears to be high enough not to limit diatom production. Nitrate concentration generally decreases downstream while nitrite appeared to be uniformly distributed throughout the river in equilibrium with nitrate and ammonia. It is interesting to compare the findings on the relationship between oxygen, nitrite and ammonia on the Chena River in the winter of 1968 with results found by Dugdale (1966) on Smith Lake, a small lake near the University of Alaska campus about 2 miles from the Chena River. It was noticed that dissolved oxygen concentration in Smith Lake decreased from 2 mg/l in January to virtually zero by March. At the same time, the nitrate concentration fell from 50 µg/l. This observation over a 3-month period on Smith Lake shows the same trend as does the December 1968 samples collected from the Chena River. Orthophosphate and total phosphate concentrations show significant increases in the lower river. These increases reflect the introduction of phosphates by sewage effluents.

Hutchinson (1957) suggests that the ratio of inorganic combined nitrogen to inorganic combined phosphorus is a limiting nutrient in the aquatic environment. He found that the ratio of nitrogen to phosphorus was 9.4 to 25.5 to 1 in the biomass in the lake. We found that in the river water, the ratio was 50 to 220 to 1. Our data shows that the total phosphate is probably the limiting nutrient in the Chena River system.

Trace metals reflect the geologic source of groundwater--principally birch creek schist, with some igneous quartz intrusion. High silica and iron result from weathering of these rocks; low sodium and magnesium indicate lack of recent igneous influences.

In Interior Alaska, iron is the cause of one of the difficulties in water treatment. The iron content of the Chena River water varies seasonally. It appears that, during the summer months, when the river is completely saturated with dissolved oxygen over most of its length, the iron concentration is fairly constant, ranging from 0.81 mg/l at station 100 to .03 mg/l at station 900. During the winter, however, the concentration increases almost in inverse proportion to dissolved oxygen, which tends to decrease rapidly downstream. The iron increased on December 30, 1968, from 0.10 mg/l at station 900 to 2.79 mg/l at station 500. The principal increase in iron occurs between stations 600 and 500, the confluence with the Little Chena.

In general, chemical oxygen demand levels are more significant as indicators of pollution in the Chena than are more specific analyses of particulate carbohydrate and protein. These are valuable, however, in determining the food sources for bacteria in the river, since bacterial metabolism is probably one of the main reasons for the reduction of dissolved oxygen during the winter.

The pH and alkalinity of the river varies seasonally. There appears to be sufficient concentrations of calcium ion throughout the year to form an equilibrium with concentrations in the shells of mollusks. However, the pH is sufficiently low in the winter to allow these shells to be eroded.

Perhaps the strongest influencing chemical characteristics of the river, if not the limiting parameter, is the dissolved oxygen content. The critical period is in the winter season when levels have approached 1 mg/l in the river above Fairbanks. The dissolved oxygen decline seems to be uniform from the headwaters to Fairbanks. As the river winds through the Fairbanks area, the thermal effect of waste discharges into the river create small reaches of open water which allows some natural reaeration to take place. The extent of the reaeration varies with the amount of open water, which, in turn, is dependent upon the severity of the winter. The cold winter of 1968-69 is reflected by the threshold dissolved oxygen levels in the lower river. Some aquatic organisms, acclimated to this environment, are capable of withstanding greater oxygen deficiencies than are generally considered acceptable. However, with oxygen levels so tenuously balanced, any slight disturbance to the ecosystem could make the lower river uninhabitable for fish and other important aquatic organisms.

### Biology

Zooplankton was represented by only two groups, Cladocera and Ostracoda, in the Chena River. The generic diversity increases toward the headwaters. This would indicate that several species of zooplankton are selectively inhibited by the changes produced in the water quality by domestic pollution.

Phytoplankton populations from the tributaries are very similar except for the Little Chena (station 100), in which only one species, Synedra ulna, is



represented. At the time of sampling, there was considerable mining activity on the upper reaches of the stream and, as a result, the stream was carrying a heavy silt load. This would explain the decreased numbers of organisms.

The periphyton show a reduction in numbers of different genera in the river from station 600 downstream (Table 20). The organisms function as saprophytes during the periods of low sunlight. The reduction is probably caused by the low dissolved oxygen levels that prevail at the lower two stations in the winter. According to Round (1962), the uptake of silica is an aerobic process depending upon respiration and high energy phosphate. Thus, the absence of almost all diatoms in water with low oxygen content may result from the inability to assimilate silica at low oxygen tensions. The bottom fauna of the Chena River show the greatest diversity in the middle section of the river, which would be expected in a river which has its headwaters in clean mountain streams and its lower reaches polluted. The data from the tributaries is very consistent, except for the Little Chena. This tributary was quite turbid because of mining operations. Apparently, the organisms present in the Little Chena are somewhat tolerant of the turbid condition, but 15 species existing in the Chena are not. This is shown by the group frequency at station 600, immediately above, which contains 22 groups.

The low temperature during the period of low flow and the flushing and dilution factors during the summer prevent the development of a septic condition with its objectional odors in the lower Chena River. With a mixed population of bacteria found in domestic sewage, this adaptive period is from 6 months to a year. If there is a year in which the flushing and dilution do not occur, it would be expected the lower 15 miles of the Chena River would experience a septic condition, in which hydrogen sulfide and mercaptan gas fumes would be pronounced. There would be a complete change in the aquatic biota of the area. The present condition exists because of the factors of temperature, time, and flow pattern of the Chena River.

The most significant fish in the Chena River is the arctic grayling. This is a sport fish providing many hours of recreation and a satisfying catch of an excellent fish.

## SECTION VIII

### ACKNOWLEDGEMENTS

We acknowledge the material contributions of Richard W. Latimer in the final stages of preparing this manuscript for publication. Collections and assay of biological materials were contributed by Theodore Roeder and Ronald Kreizenbeck. Ronald Gordon made the coliform counts.

Considerable assistance and fisheries data was furnished by the State Department of Fish and Game personnel (Fairbanks Office) in the preparation of the section on Fisheries. The U. S. Army Corps of Engineers (Alaska District Office, Anchorage) provided the basic data and drawings relative to the Chena Flood Control Project

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SECTION X  
GLOSSARY OF TERMS

- acidic-acid forming; containing an excess of acid forming substance
- aerobic-requiring elemental oxygen for metabolism
- alkalinity-measurement of amount of base in a solution
- anaerobic-having the ability to maintain respiration without utilization of elemental oxygen
- anadromous-fish which travel from the ocean to fresh water to spawn
- artificial substrate-strip of glass, masonite, or wood suspended in a stream to collect periphyton
- autochthonous-pertaining to those organisms originating within a particular waterway and remaining in that waterway
- benthos-community of living organisms on the bottom of a body of water
- biochemical oxygen demand (BOD)- amount of oxygen necessary to oxidize the organic materials present by biological means
- biota-the fauna and flora of a region
- biotic factors-biologically derived environmental conditions affecting the biota
- break up-period when warmer temperature brings on melting of snow and ice cover and run-off water causes a rise in discharge and movement of ice
- chemical oxygen demand (COD)-amount of oxygen necessary to oxidize the organic materials present by chemical means
- coliform-organisms associated with the intestinal tract of animals, i.e. the colon of warm blooded vertebrates
- colony-a distinguishable localized population within a species
- community-all forms of life inhabiting a common environment
- conductivity-measure of the ability to transmit an electrical current
- consumers-organisms which feed on other organisms

culture-cultivation of organisms in a medium containing necessary nutrients

decomposers-organisms, bacteria and fungi, which break down complex organic materials into simple compounds

diatoms-any of the algae in which the shell has two siliceous frustules

dissolved oxygen (DO)-elemental oxygen in solution

diversity-pertaining to the variety of species within a given community of organisms

ecological factor-any part or condition of the environment that influences the life of one or more organisms

ecosystem-the total environment including all component organisms and all biotic factors

effluent-flowing out, i.e. a sewer outfall into a stream

facultative-the capability of an organism to live under varying conditions

flora-plant life

food chain (food web)-the flow of energy in an ecosystem through successive feeding processes based upon a fundamental primary producer community

food cycle-the interconnecting food chains in an environment

freeze up-time when ice begins forming in a stream

gaging station-measuring point of discharge of a stream

indigenous-organisms native to the water in which they are collected

instar-a stage in the life cycle of an insect or other arthropod between two successive molts

invertebrates-animals without an internal skeleton (insects, mollusks, crayfish, etc.)

lotic-flowing waters such as streams and rivers

lentic-standing (non-flowing) waters, lakes, ponds, or swamps

limnology-study of the biological, chemical, physical, and geographic features of fresh water, especially ponds and lakes

metamorphoses-change of an animal from one distinct life history stage to another

mg/l--ppm-milligram per liter-parts per million

nutrient-those combined fundamental elements or compounds necessary in metabolism or primarily productivity; particularly nitrogen and phosphorus

parameter-any one chemical or biological determination

pathogenic-capable of causing a diseased condition in plants or animals

photosynthesis-reaction of carbon dioxide through biological process requiring solar energy with other inorganic compounds to form organic compounds

phytoplankton-microscopic plants capable of no or limited movement in a water mass

pollution-addition of any material which tends to degrade water quality with respect to a particular use

productivity-measurement of rate of photosynthesis

reach-section of a stream between two named positions

reaeration-solution of oxygen into natural water systems

respiration-the physical exchange of gases by an organism with the immediate environment

riffle-rapidly moving reaches of a stream where shallow water runs over stones and gravel

saprophytes-organisms, bacteria and fungi, which secure their energy from non-living organic matter

sewage-waste matter, human, animal, or industrial

solar radiation-sunlight

spawning-deposition of eggs and sperm in a stream or lake

species-a term used in classification to denote a group of closely allied, mutually fertile organisms showing constant differences from other allied groups

zooplankton-microscopic animals capable of only limited movement in the water





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